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Summary of the 2007 Herring Acoustic Surveys in NAFO Divisions 4VWX

Résumé des relevés acoustiques sur le hareng effectués en 2007 dans les divisions 4VWX de l'OPANO

M.J. Power and G.D. Melvin

Population Ecology Section
Department of Fisheries and Oceans
St. Andrews Biological Station
531 Brandy Cove Road
St. Andrews, New Brunswick
Canada E5B 2L9

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ABSTRACT

Automated acoustic recording systems deployed on commercial fishing vessels have been used since 1997 to document the distribution and relative abundance of Atlantic herring in Northwest Atlantic Fisheries Organization (NAFO) divisions 4VWX from industry vessel surveys and fishing excursions. In 2007, regularly scheduled surveys at approximately 2-week intervals were again conducted on the main spawning components, and the spawning stock biomass for each component was estimated by summing these results. Four structured surveys were conducted in Scots Bay, 4 on Trinity Ledge, 3 in the Spectacle Buoy area and 5 on German Bank, with most following the established protocol. These surveys provided good coverage of the spawning areas consistent with established protocols in most cases. Additional data from fishing nights on German Bank were also examined but were not applied to the overall spawning stock biomass (SSB). Biomass estimates in the traditional survey areas for Scots Bay, Trinity Ledge and German Bank were 384,400t, which is an increase of approximately 100,000t from 2006. The 2007 SSB estimate remains below the long term average.

Biomass estimates from surveys of the coastal Nova Scotia spawning components for the Little Hope/Port Mouton, Eastern Shore and Glace Bay areas were also examined and showed declines in all areas. No acoustic surveys were conducted in the Bras d'Or Lakes in 2007. There were some large aggregations of herring observed and reported for the offshore Scotian Shelf, but no acoustic surveys were completed.

RÉSUMÉ

Des systèmes d'enregistrement acoustiques automatiques installés sur des bateaux de pêche commerciaux sont employés depuis 1997 pour documenter la répartition et l'abondance relative du hareng dans les divisions 4VWX de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO) dans le cadre de relevés de l'industrie et de sorties de pêche. En 2007, on a effectué, à environ deux semaines d'intervalle, des relevés des principales composantes de reproducteurs; on a ensuite évalué la biomasse du stock reproducteur de chaque composante en additionnant les résultats obtenus. Quatre relevés structurés ont été réalisés dans la baie Scots, 4 dans le récif de la Trinité, 3 dans la zone de la bouée Spectacle et 5 sur le banc German, généralement conformément au protocole établi. Ces relevés ont assuré une couverture satisfaisante des frayères, globalement cohérente par rapport aux protocoles établis. Des données supplémentaires recueillies au cours de nuits de pêche sur le banc German ont également été examinées, sans être appliquées à la biomasse globale du stock reproducteur. Les estimations de la biomasse pour les zones de relevé habituelles de la baie Scots, du récif de la Trinité et du banc German étaient de 384 400 tonnes, ce qui correspond à une augmentation d'approximativement 100 000 tonnes depuis 2006. L'estimation de la biomasse du stock reproducteur pour 2007 demeure toutefois en-dessous de la moyenne à long terme.

Les estimations de la biomasse à partir des relevés des composantes de reproducteurs des côtes de la Nouvelle-Écosse pour les secteurs de Little Hope/Port Mouton, de la côte Est et de Glace Bay ont également été examinées : une diminution de la biomasse a été observée pour tous ces secteurs. Aucun relevé acoustique n'a été réalisé dans le lac Bras d'Or en 2007. De grandes concentrations de harengs ont été observées et signalées au large du plateau néo-écossais, mais aucun relevé acoustique n'a été effectué.

INTRODUCTION

Since 1997, the spawning stock biomass (SSB) of NAFO divs. 4WX herring has been estimated using acoustic surveys conducted by the fishing industry (Melvin et al. 1998; Stephenson et al. 1998). Each year, commercial fishing vessels equipped with calibrated acoustic logging systems undertake both scheduled and unscheduled surveys of herring aggregations on the spawning grounds. The data collected during these surveys serve 2 purposes. First, when necessary, the data can be analyzed in near real-time, and used as input for the "survey, assess, then fish" protocol, to apportion fishing effort on individual spawning grounds. Secondly, the estimates for individual spawning areas have been summed, under specific assumptions about elapsed time between surveys, to provide an annual index of the SSB for the assessment process. The development and implementation of the automatic acoustic systems represents a major improvement in quantifying fish biomass. Pre-1997 estimates relied on the experience of the observer to estimate the amount of fish from mapping surveys, and are considered qualitative only (Melvin et al. 2002a).

The use of commercial fishing vessels to survey and to estimate SSB was initially developed to provide additional protection of individual spawning components within a global total allowable catch (TAC) during a period (1994-95) of declining biomass. The original qualitative approach, commonly referred to as the "survey, assess, then fish" protocol, continues today, but now uses a quantitative acoustic methodology with a standard survey design (DFO 1997; Melvin and Power 1999; Melvin et al. 2004; Power et al. 2004, 2005a, 2006a) to provide an index of spawning biomass.

Several major improvements to our approach have been made in the areas of survey design and in the standardization of survey coverage to a point where they can be considered comparable from year to year (Melvin and Power 1999; Melvin et al. 2003, 2004; Power et al. 2003, 2004, 2005b). The purpose of this document is to report and to summarize the NAFO divs. 4VWX stock assessment related survey data collected during the 2007 fishing and survey season.

METHODS

Acoustic and mapping surveys using commercial fishing vessels have been employed to estimate the spawning stock biomass of individual components within the stock complex since 1999. The methods and procedures are well established and described in more detail in previous research documents (Melvin et al. 2004, Power et al. 2005a, 2006a).

Data from the 2007 fishing season were obtained during both standard fishing operations and regularly scheduled structured surveys. Structured surveys were either mapping and/or acoustic surveys (Melvin et al. 2001). In 2007, no major changes from previous years were made to the established protocol for either acoustic or mapping surveys.

The 16 surveys scheduled for 2007 were completed on or near the dates planned, and an additional 7 fishing night recordings were examined in order to enhance coverage (Table 1). Additional surveys were completed in order to either increase coverage or to ensure that newly observed groups of fish were recorded, bringing the total number of structured surveys to 26. The total number of survey boat nights completed was 133, with 61 from vessels with acoustic recording systems (Table 2).
In general, structured surveys were conducted in accordance with the protocol established in Melvin and Power (1999). When structured surveys were undertaken, participating vessels

tended to follow standard protocol and there was usually good coverage of the defined spawning survey area.

A few exceptions to the normal protocols of survey design did take place and these are explained in more detail where they occur below.

Data Quality Issues

In the previous analysis, there were 3 main areas of concern with the data including surveying protocols, provision and verification of the raw data and editing, and issues of noise and interference (Power et al. 2006b). In the 2007 season most of these issues were resolved, but some, like not following survey protocols on non-survey nights, continue to be a problem.

There is a well defined survey protocol for structured surveys and fishing night school documentation, but these were not always followed and remain an issue. In cases of fishing night surveys by purse seine vessels, there was very poor adherence to survey design with vessel captains rarely establishing a series of parallel transects to document the fish. Rather, the data provided was usually one of an unorganized search pattern common in fishing operations and was very difficult to analyze. It is important to follow the protocol (of a series of stepped parallel lines) for surveying an aggregation or school of fish. Data collections inconsistent with established protocols were again given a low priority for analysis or were not processed.

A major portion of time is required to download, backup and edit the raw acoustic survey data files. In previous years, Department of Fisheries and Oceans (DFO) staff completed this task and received all 'original' raw data files (unedited). More recently, these tasks have been split between the Herring Science Council (HSC) and DFO with the complete raw data received at the end of the season. In the previous review, it was recommended that all raw data files be made available on a regular basis for review prior to finalizing the acoustic biomass estimates. In 2007, all raw data files were received and the data compared with the edited results before the final analysis was completed. The main reason for these comparisons is to check for target uncertainty, to distinguish fish from bottom and to examine interference/noise patterns. As a result of these examinations, some data problems were found and resolved with some vessels and for specific surveys. In a few cases, the bottom was not completely removed and some non-herring species were apparent.

In the previous year, vessel noise/interference was apparent for some of the raw data files examined. The solution for future analysis is to have raw data files made available and examined at regular intervals, and at the first sign of problem the source is determined and corrected, if possible. In addition, the operational vessel speed should be determined for each vessel and surveying speed limited to this. In 2007, noise tests were again completed for each vessel as part of the calibration process, and recommended speed or vessel RPM levels were made. As a result of these efforts, the resulting raw data collected was found to have less background noise and was useable from all survey vessels.

Length/Weight Relationship

Prior to 2001, the fish weight variable in the target strength (TS) equation (Table 3) was estimated using a length/weight relationship developed from monthly data for each area. A correction factor of 1.02 was also applied to each length measurement to account for the shrinkage of fish due to freezing, prior to calculating the length/weight relationship (Hunt et al. 1986). This relationship was then used to estimate the weight of a fish for a given length.

The time window used to select data appropriate for individual surveys has narrowed slightly since 2001, to provide a more representative estimate of mean fish weight. Recent initiatives and continued collaboration with the processing plants have greatly improved sampling, such that it is now possible to obtain a significant number of detailed samples (length/weight data) within a 9-day window (4 days prior to or after each of the surveys). These data are used to develop a weight/length relationship specific to each acoustic survey (Table 3). The mean length of herring sampled during the night of the survey (or from landings of the previous night) and the calculated mean weight is then used to estimate TS specific to each survey period.

Integration Calibration Factor

In 2003, an option to account for the non-square waveform observed in a ball calibration was incorporated into the HDPS software (Melvin, et al. 2004). This approach is used by several acoustic manufacturers when calibrating their echo sounders. The effect of including an integration calibration factor to estimate backscatter in the integration process varies depending on the vessel's acoustic hardware. The multiplier for the factor, which is applied to the standard calibration, typically lies between 0.4 and 1.6, with 1.0 equivalent to an ideal square wave and, thus, no adjustment.

Given that the inclusion of the integration calibration factor (ICF or CIF) is deemed to provide a more accurate estimate of biomass, it was recommended that all future analyses utilize the CIF to calculate absolute biomass (Melvin et al. 2004). However, when comparing observations from year to year, it was recommended that the comparisons be made between biomass estimates that exclude the adjustment, until a time series has been established with the CIF included. After several years, only the biomass estimate with the CIF will be needed.

The following analysis presents results using both methods of calculation (with and without the CIF). Comparisons between years are made only with data calculated without the CIF, since it has not yet been possible to recalculate the estimates for all earlier years using the CIF. Unless otherwise noted in the text, only biomass estimates without the CIF will be referred to when summarizing the data results. The reader may refer to the appropriate tables to see the estimates calculated in both ways.

Acoustic Systems

In 2007, as in previous years, acoustic data were collected using automated logging systems aboard commercial fishing vessels during both standard fishing excursions and structured surveys. The systems, which were activated whenever the captain wished to document observations, automatically saved all data to the system's hard drive. The data were downloaded at regular intervals prior to archiving, data editing and summary analysis.

A total of 16 automated acoustic logging systems were deployed on commercial fishing vessels in 2007. Systems from FEMTO Electronics were installed and/or re-calibrated aboard 9 purse seine vessels, *Brunswick Provider, Canada 100, Dual Venture, Island Pride, Lady Janice, Lady Melissa, Leroy & Barry, Margaret Elizabeth* and *Secord*. There were also 2 SIMRAD ES-60 acoustic systems calibrated and used on the purse seine vessel *Morning Star* and the combination seiner/midwater trawler *Julianne III*. There were 5 FEMTO systems on the inshore herring gillnet vessels including the *Bradley K, Jessica & Trevor, Knot Paid For, Miss Owl's Head* and *Natasha Lee*.

Structured Surveys

Structured surveys are defined as those surveys that follow the standard protocol described by Melvin and Power (1999). Under this protocol, commercial vessels follow a series of randomly selected transects within a pre-defined area. The number of transects depends upon the number of vessels involved. Acoustic recording vessels are distributed throughout the survey area to provide representative coverage. The surveys conducted periodically throughout the spawning season are generally scheduled at 2-week intervals. These surveys play an important role in the understanding and perception of the 4WX herring stock. Sufficient flexibility is built into the process to allow for schedule changes and for investigation of areas of interest or uncertainty. Structured surveys were conducted on each of the major, and several of the minor, spawning grounds within 4WX, and additional recordings were made of both spawning and non-spawning aggregations during fishing night operations.

Fishing Excursions

Fishing nights are defined as those occasions when acoustic data are collected by fishing vessels equipped with automated acoustic logging systems during the search phase of a fishing excursion. These data, which often do not follow any formal survey design, provide information on the distribution and abundance of herring during non-survey nights. The data have also been used in the past to document large spawning aggregations not included in a survey and/or as a substitute for a survey, in the event that no other information is available. The approach to the activation of the systems has changed since the start of the program. During the early stages, fishing captains would turn their system on when they reached the fishing ground and off once they deployed their fishing gear. For the last few years, the majority of vessels have activated their systems only when they believed there was something worth recording. This has greatly reduced the amount of time required for archiving, editing and analyzing.

Analyses of acoustic data from non-survey nights have increased due to the provision of technical support from the Herring Science Council since 2002. Due to the reduction of this support in 2007, data from fishing nights were examined only for the German Bank area (Table 4). All fishing night estimates for the German Bank areas were found to be lower than the nearest survey estimate for that spawning area, and time period and were not used further in the overall area estimates.

RESULTS

The spawning biomass for individual components of the 4WX herring stock complex in 2007 was estimated from industry collected data using multiple structured acoustic and mapping surveys on major spawning grounds (Figure 1). These surveys, when summed, provided an index of SSB and formed the foundation for evaluation of the stock status. The following text provides a summary of the 2007 observations and SSB estimates for each of the main spawning components within the stock complex.

Bay of Fundy/SWNS Spawning Component

Biological Sampling for Maturity

The timing of surveys in relation to the residence time of spawning groups on the spawning grounds continues to be an issue of major concern. The current hypothesis for surveys on individual spawning grounds assumes that there is constant spawning on each ground over the

season with individual spawning groups or waves continuously arriving, spawning and then leaving within 10 to 12 days (or less).

Sampling data for maturity supports the view of continuous spawning or waves with high proportions of ripe and running (spawning/Stage 6) fish observed over an extended period. The 10 to 12 day window also assumes that there will be no double counting and that the maturing (hard/Stage 5), as well as the spawning (Stage 6) fish in the samples will also have spawned and left before the next survey.

In 2007, herring maturity data were again obtained from 2 primary sources: "Herring Roe Analysis Sheet" data from the Scotia Garden Seafood processing plant quality control group and samples from the standard biological sampling program conducted by staff at the St. Andrews Biological Station (SABS). The "Roe Analysis Sheets" from Industry were supplied as available, usually on a daily basis during the spawning period and often with multiple samples from different boats. These are random samples of 50 to 100 fish with the males and females separated, and the individual gonads weighed into categories for use by the processing plant. From these data, the overall percent weights of mature, immature and spent females, as well as percent weight of the male gonads were determined.

The SABS biological samples provide data on individual fish for length, weight, sex, maturity stage, gonad weight and age. These samples are collected from various sources including research surveys, tagging trips and acoustic surveys, and from landings at various plants. For comparison with the industry categorization, a modification to the SABS lab procedure to weigh all gonad stages was implemented in 2003. SABS samples were combined for female fish by day and percent numbers and percent weight by the categories determined. The plant classification system of maturity must not be confused with the standardized ICES (International Council for the Exploration of the Sea) scientific scale of 1 to 8 (Parrish and Saville 1965), but the industry roe data can be compared with SABS data based on knowledge of the 2 methods. Analysis of the roe maturities was completed for the data available on an individual survey basis and is presented with the details for each survey completed.

Spawning Ground Turnover Rates

The current acoustic survey method on spawning grounds is dependent on the assumption of periodic turnover of spawning fish on the spawning grounds. Acoustic surveys are required to be separated by at least 10 to 14 days to allow for turnover and to prevent double counting (Power et al. 2002). This aspect of the assessment method was the subject of investigation in 2001 and of intensive sampling for maturity stage since that fishing season. The results and application to the acoustic surveys are summarized by Melvin et al. (2002b, 2003, 2004; Power et al. 2005a, 2006a), and were used to assist in the evaluation of turnover timing and the inclusion or exclusion of specific acoustic surveys.

From 1998 to 2002, the Pelagics Research Council/Herring Science Council, in partnership with DFO, tagged herring on spawning grounds and on the major Nova Scotia over-wintering grounds. Although this project has concluded, tags continue to be returned. The information on tags returned from this study has been summarized by Waters and Clark (2005). Evidence from tagging experiments conducted in 1998 of ripe and running (spawning) herring showed that the residence time for most returns on the same grounds was less than 7-10 days; however, 25% of returns were captured on the same grounds after more than 10 days at large (Paul 1999). In contrast, a similar experiment in September 2001 on German Bank showed no recaptures after 9 days on the same grounds during the same spawning season (Power et al. 2002). This latter

result was complicated by a large decrease in fishing effort (and thus returns) during the second week after tagging.

In response to a recommendation from the 2005 Regional Advisory Process (RAP), tags were applied to herring on the spawning grounds of Scots Bay and German Bank (Clark 2006). The results from the tag returns indicated that some tagged herring remained on the spawning grounds for at least 3 weeks after tagging and, in some cases, up to 5 to 6 weeks after tagging. Thus, acoustic surveys that were spaced at 2-week intervals were surveying some of the same fish twice or possibly even 3 times.

These results have serious implications in how the acoustic surveys are evaluated and used to determine stock status. Some preliminary analysis has been completed comparing 3 different approaches for the interpretation of the acoustic biomass estimates in an absolute sense (Power et al. 2006a). The results showed that caution is warranted when employing the cumulative biomass estimates as absolute in any of the survey areas. The results also indicated that some proportion of herring remain in the survey area even 3 weeks or longer.

A framework assessment meeting in January 2007 determined that double counting does occur, but the extent has not been well determined (DFO 2007). However, it was still recommended to continue to do surveys at 10-14 day intervals to avoid double sampling. The timing/turnover issue was considered to be of highest importance for further study, which should include work on the duration of the maturation process, further tagging with more frequent intervals to estimate turnover rates and increased survey frequency to reflect maturity stage duration.

Acoustic Surveys

Scots Bay

The Scots Bay herring purse seine fishery has been an important component of the summer fishery with catches since 1987, ranging from 1,000 to 24,400t during the period of early July to late August-early September. The 2007 fishery was restricted due to the poor performance of the spawning component since 2005.

Four structured surveys were conducted during the 2007 spawning season in Scots Bay similar to previous years (Table 2). The surveys, which began about the same time as in recent years, were separated by a minimum of 13 days and provided good coverage of the survey area.

Scots Bay Acoustic Survey #1: July 14, 2007

The first herring acoustic survey of Scots Bay in 2007 had 3 vessels participating; *Canada 100, Brunswick Provider* and *Margaret Elizabeth,* all with acoustic recording systems. The survey was led by Jack Fife of SABS, and helpful suggestions on survey execution were made by the skippers of the 3 purse seine vessels, which improved operation of the survey. The vessels met off Margaretsville at 2100hr near the southwest margin of the survey box, and each vessel ran lines 1.5nm apart so that SONAR would overlap and schools of herring would not be missed by the survey. The vessels also documented some areas of fish which were missed by random lines, but seen to one side or other by SONAR (Figure 2). Herring were observed from the sounder recordings, mostly along the northern edge of the survey and spawning box and into Advocate Bay. Catches for the period from July 14th-23rd, nearest in time to this acoustic survey, were also from the same area.

Three length frequency samples were collected from fishing which took place on the night after the survey. A mode is evident at 29cm and the mean size was 28cm with a range from 21 to 33cm (Figure 3). There was a small proportion (2.2%) of the samples with size <23cm, which is the size at first maturity and may indicate immature fish. However, all herring sampled were mature with ripe and running gonads (Stage 6) (Figure 4). Biological samples from July 15th-16th provided sufficient numbers (60 fish) for the calculation of the length-weight regression used in the estimation of target strength. The resulting TS estimate of -35.66 was only slightly different from the standard TS of -35.5 for a 28cm herring, which is used when no samples are available (Table 3).

The data were downloaded from the 3 boats with acoustic recorders by L. Boudreau, and the initial data editing was completed by A. Clay. The 3 vessels with recorders completed 7 approximately equally spaced lines with occasional diversions from the line to document schools of fish near the lines (Figure 2). The transects were grouped into 3 areas: lines within the survey box, lines to the east of the survey box and lines to the north of the survey box, with estimates calculated from the line segments in each of these areas both with and without the CIF (Table 5).

Estimation of the schools was difficult since the pattern of lines was not a series of parallel lines, and due to problems of area estimation. In future, it would be beneficial if a grid pattern was completed on major schools with at least 3 or 4 lines in each direction through each school. A total of 5 schools were covered, with a total biomass estimate for the schools summed of 4,265t without the CIF and 4,706t with the CIF. These estimates were not used further, since the overall estimate for the entire area was shown to be larger.

As recommended at the Herring Framework review, the standard survey box area of 636km^2 was used for comparability between years. Within the standard survey box, an adjustment was made for lines that were incomplete. The distance was extended to the length of the box and assessed as no fish where there were no observations. The biomass estimate from this survey for herring located within the standard survey box area (inbox) was 8,027t without the CIF and 8,680t with the CIF (Table 5). The estimates from this survey for herring located outside of the standard survey box area (outbox) was 181t without the CIF and 219t with the CIF (Table 5).

Scots Bay Acoustic Survey #2: July 28, 2007

The second herring acoustic survey of Scots Bay in 2007 took place on the evening of July 28th with Jay Lugar of the Herring Science council attending. Four vessels participated: *Canada 100, Brunswick Provider, Margaret* Elizabeth and *Secord,* and all boats were equipped with acoustic recording gear. The vessels met off Margaretsville at 2130hr and each vessel ran lines which had been pre-established by SABS staff (Figure 5). A large school of fish was encountered along one of the survey lines (by the *Canada 100* and *Brunswick Provider*) and additional time was spent running lines over this aggregation before resuming the survey lines. The other survey lines only encountered small amounts of herring at various intervals. No lines were scheduled north and east of Île Haute, where a few boats had been fishing earlier the week before, and there was insufficient time to return to that area following the completion of the survey, especially given the tide direction at the time. Herring were observed from the sounder recordings mostly in the central and western part of the survey box. Catches for the week of July 24th-31st, closest to this survey, were mostly from these same areas, but included a few landings to the north near Advocate Bay where no surveying took place. The survey ended at 0300hr on July 29th.

Length sampling available from fishing nights both before and after the survey showed small differences in mean size and the overall length range. Two length frequency samples collected from fishing, which took place on the night after the survey, were used in the estimation of target strength (Figure 6). A mode is evident at 27.5cm and the mean size was 27.1cm with a range from 22.5 to 33cm. There was a small proportion (0.8%) of the samples with size <23cm, which is the mean size for first maturity and may indicate immature fish. However, most herring sampled on July 31st were mature with ripe and running gonads (Stage 6). Biological samples from July 15th-16th provided sufficient numbers (107 fish) for the calculation of the length-weight regression used in the estimation of target strength (Table 3).

The data were downloaded from the 4 boats with acoustic recorders by L. Boudreau, and the initial data editing was completed by A. Clay. The 4 vessels with recorders completed 8 approximately equally spaced lines with diversions from the lines to document schools of fish near the lines (Figure 5). The transects were grouped into lines within the survey box and lines done separately for the school encountered with estimates calculated from the line segments in each of these areas both with and without the CIF.

Estimation of the school was again difficult, since the pattern of lines was not a series of parallel lines by both vessels and due to problems of area estimation. The single school was covered by 2 vessels with an average biomass estimate for the school of 4,570t without the CIF and 5,300t with the CIF. The school estimates were done to confirm the biomass of the school in relation to the survey box estimate, and will not be used further as part the overall survey sum. Since the school was encountered along the standard survey lines, it is already included as part of the overall survey box estimate based on the transect density along that line.

As recommended at the Herring Framework review, the standard survey box area of 636km^2 was used for comparability between years. Lines were adjusted to stay within the standard survey box and checked to ensure that there was no fish outside of the survey box area. The final biomass estimate for the standard survey box area was 29,240t without the CIF and 31,960t with the CIF (Table 5). There were no data for estimation of herring outside of the survey box area for this survey.

Scots Bay Acoustic Survey #3: August 11, 2007

The third herring acoustic survey of Scots Bay in 2007 took place on the evening of August 11th, with the captains of the purse seine vessels managing the survey using pre-assigned lines. Five vessels participated and all, except the *Fundy Mistress,* were equipped with acoustic recording gear. One vessel, the *Morning Star,* was equipped with a Simrad ES-60 sounder and recording system rather than the typical FEMTO echo sounder and recording system.

The vessels met off Margaretsville at 2100hr and each vessel ran pre-established lines received from SABS staff. Additional recordings were made to the northeast of the survey box near Halls Harbour and for deviations from the assigned lines when schools were encountered during the survey. Herring were observed from the sounder recordings mostly in the northeastern part of the survey box. Catches for landings made after this survey from August 13th-14th were in a different area spread from Halls Harbour south to the central portion of the survey box. The survey ended at 0200hr.

Length frequency samples from fishing nights closest to the survey showed small differences in mean size and the overall length range. Three samples collected from fishing on the night after the survey were used in the estimation of target strength (Figure 7). The mean size from 386 fish was 27.6cm with a range from 23 to 34cm. All fish sampled were larger than 23cm (the

mean size at first maturity) and 9.8% were greater than 30cm. Most herring sampled on August 13th-14th were mature with ripe and running gonads (Stage 6). Biological samples from August 7th-14th provided sufficient numbers (119 fish) for the calculation of the length-weight regression used in the estimation of target strength (Table 3).

The data were downloaded from the 3 boats with FEMTO acoustic recorders by L. Boudreau, and the initial data editing was completed by A. Clay. The data for the SIMRAD acoustic recording system was downloaded by R. Cunningham, and the data editing was completed by G. Melvin. Four vessels with recorders completed 8 approximately equally spaced lines (Figure 8). Diversions were made from the lines to document schools of fish, but the vessels did not return to the point of origin where they had left the survey transect, as the protocol describes.

The Simrad ES60 data were edited and analyzed using the Echoview software package with calibration parameters specific to the *Morning Star* (Figure 9). The Echoview output option for mean area backscatter in dB/m^2 is equivalent to the HDPS mean Sa by transect. Note that the backscatter from the ES60 is only comparable to the CIF adjusted transect densities.

Transects were grouped into lines within the survey box (inbox), outside of the survey box (outbox) and lines for 3 schools encountered off the designated lines. Estimates were calculated using the line segments for each of these groups both with and without the CIF. The area just southeast of Cape D'Or outside of the survey box (outbox) was estimated using the 3 available lines within an area of $20km^2$ (Table 5). Estimation of the biomass for schools is difficult when the survey pattern is a series of loops through the fish and not a standard series of parallel lines (Figure 8). School estimates were made in order to confirm the biomass of the school in relation to the overall survey box estimate. Schools encountered within the standard survey area are considered to be included based on the average transect densities along all the lines. The 3 individual schools covered had a total biomass estimate of 4,610t without the CIF and 5,000t with the CIF. but these data were not used in the overall biomass estimate for the reasons stated above.

As recommended at the Herring Framework review, the standard survey box area of $636km^2$ was used for comparability between years. Lines were adjusted to stay within the standard survey box. The final biomass estimate for the standard survey box area was 6,580t without the CIF and 7,870t with the CIF (Table 5). The biomass estimate for the 'outbox' box area was 800t without the CIF and 940t with the CIF (Table 5).

Scots Bay Acoustic Survey #4: August 25, 2007

The fourth and final herring acoustic survey of Scots Bay in 2007 took place on the evening of August 25th, with the vessel captains managing the survey using pre-assigned lines. Four purse seine vessels, all equipped with acoustic recording gear, participated in the survey. The vessels met off Margaretsville at 2100hr, and ran pre-established lines provided by SABS staff. Additional acoustic coverage was undertaken to the northeast of the survey box between Cape Spencer and Halls Harbour. The survey ended at 0200hr.

Very little herring were observed from the sounder recordings within the survey area, but a few schools were found outside of the survey box off Halls Harbour. Catches for landings close in time to this survey from August 20th-31st were spread from Halls Harbour southwest to the central portion of the survey box (Figure 10).

Three length frequency samples collected from fishing on the night after the survey were used to estimate target strength (Figure 11). The mean size for 341 fish measured was 27.5cm with a range of 22.5 to 33cm. Most fish sampled were larger than 23cm (mean size at first maturity) and 6.5% were greater than 30cm. Herring sampled for maturity just before the survey on August 20th were all mature with hard (Stage 5) or ripe and running gonads (Stage 6). No other biological samples were available.

A single biological sample from August 20th (35 fish) was used to calculate the length-weight regression for estimation of target strength in terms of weight. The standard TS of -35.5 for a 28cm herring, which is used when no samples are available, is only slightly different from the -35.525 derived from length frequency and biological samples for this survey (Table 3).

The acoustic data were downloaded from the 4 boats by L. Boudreau and B. Saulnier, and the initial data editing was completed by A. Clay. The 4 vessels with recorders completed 8 approximately equally spaced lines within the survey box area, as well as a series of lines northeast of the survey box (Figure 10). Transects were grouped into lines within the survey box (inbox) and outside of the survey box (outbox) for 3 schools encountered outside of the survey area.

The 3 individual schools outside of the survey box (outbox) had a total biomass estimate of 1,003t without the CIF and 1,080t with the CIF (Table 5). The final biomass estimate for the standard survey box area was 1,845t without the CIF and 1,953t with the CIF (Table 5).

In summary, the 2007 Scots Bay acoustic survey SSB estimate from the 4 structured surveys for the within survey box area (inbox) was 45,700t as calculated without the CIF and 50,460t with the CIF (Table 5). For 2007, the total estimates for areas surveyed outside of the standard survey box in the Scots Bay area were 1,980t without the CIF and 2,240t with the CIF (Table 5).

German Bank

The German Bank herring purse seine fishery has been a major component of the summer fishery with catches since 1985, ranging from 9,000 to 36,000t during the overall fishery period of early May to late October (Power et al., 2009). Catches during the spawning period in 2007 were very similar to those of 2006, but were slightly more widespread with 2 localized groups of spawning herring seen within the standard survey area on German Bank.

Five acoustic surveys were conducted on German Bank during the 2007 season between August 24th and October 17th covering the entire spawning period (Table 6). Only 4 surveys were counted in the total biomass estimate due to survey protocol problems in the final survey. The time interval between surveys ranged from 12 to 14 days, and a total of 38 vessel nights of surveying were completed (Table 2). In addition to the acoustic recordings, visual observations from the sounder were recorded at 5 to 10 minute intervals on deck sheets for all vessels. Fish samples for maturity, while limited from industry sources, indicated that mature spawning herring dominated samples collected. The early and late surveys were dominated by predominately ripe and running fish, while the middle 2 surveys contained about 15% mature (Stage 5) herring. As in previous years, length sampling was very extensive for this fishery with fish sampled from within the survey box found to be mostly larger than 23cm, which is the approximate size of first spawning for this stock. Pre-spawning herring of less than 23cm were generally infrequent in 2007.

Fishing night acoustic data for German Bank were examined for 7 nights between August 22nd and September 19th, where sufficient data for estimation of biomass were collected (Table 4).

Biomass estimates from these fishing nights ranged from 3,300 to 47,700t. All estimates were found to overlap with survey nights in the 10 day spawning timing window and were lower than the total SSB from the 4 structured surveys. No fishing night data were used in the final SSB for German Bank.

German Bank Acoustic Survey #1: August 24, 2007

The first herring acoustic survey of the German Bank spawning area for 2007 took place on the evening of August 24th-25th with Jay Lugar from the Herring Science Council attending and with the captains of the purse seine vessels managing the survey using pre-established lines received from SABS staff. Nine vessels participated, 5 of which were equipped with acoustic recording gear (Figure 12, 13). The vessels met at the northern boundary of the survey box at 2100hr and each vessel ran 2 pre-assigned lines. Additional recordings were made to the north of the survey box, but there was not a significant amount of fish in this area. Herring were observed at light and medium densities from the sounder recordings, mostly in the upper part of the survey box with little or nothing in the lower half. Catches for landings made before this survey from August 1st-24th were spread over a similar area from the north to the central portion of the survey box. The survey ended at 0230hr and no fishing took place on the survey night as per prior agreement.

Four samples collected from fishing on the night before the survey were used in the estimation of target strength (Figure 14). The mean size was 29.2cm with a range from 23 to 34cm. All fish sampled were larger than 23cm (the mean size at first maturity) and 25.7% were greater than 30cm (approximately 5-6 years old). A single sample available on August 22nd for maturity showed herring were mature with ripe and running gonads. Biological samples from both industry and SABS sources provided sufficient numbers (399 fish) for the calculation of the length-weight regression used in the estimation of target strength. The TS estimate calculated for a 38/50kHz frequency system of -35.768 differs by 0.278dB from the standard TS of -35.5 for a 28cm herring used when no samples are available (Table 3). The increase in mean size and weight and resulting change from standard TS increased the SSB by approximately 6%

After the data were downloaded from the 4 boats with FEMTO acoustic recorders, the initial editing for these data was completed by A. Clay. Data for the SIMRAD system was downloaded by R. Cunningham and the editing was completed by G. Melvin. The 5 vessels with recorders completed 10 approximately equally spaced lines (Figure 12, 13). Transects were grouped into lines within the survey box (inbox) and lines outside of the survey box (outbox) (Figure 12). Biomass estimates were calculated using the line segments for each of these groups both with and without the CIF.

The Simrad ES60 data were edited and analyzed using the Echoview software package with calibration parameters specific to the *Morning Star* (Figure 13). The Echoview output option for mean area backscatter in dB/m^2 is equivalent to the HDPS mean Sa by transect. These backscatter results from the ES60 are only comparable to the Calibration Integration Factor adjusted (with CIF) transect densities provided by the FEMTO system.

In previous years, herring observed north of the survey box were found to be primarily small juvenile fish and not considered to contribute to the SSB. While there were no samples from this area and time to confirm the size as adult, there was a lack of juvenile size fish during the 2007 season on German Bank. The biomass estimate for the area north of the survey box was 2,800t without the CIF and 4,000t with the CIF (Table 6). As recommended at the Herring Framework review, the standard survey box area of $646km^2$ was used for comparability between years. The final biomass estimate for the standard survey box area was 27,900t without the CIF and

42,000t with the CIF (Table 6).

German Bank Acoustic Survey #2: September 7, 2007

The second herring acoustic survey of the German Bank spawning area took place on the evening of September 7th-8th with Jay Lugar from the Herring Science Council attending, and with the captains of the purse seine vessels managing the survey using pre-established lines received from SABS staff. Ten vessels participated, 7 of which were equipped with acoustic recording gear (Figure 15, 16). The vessels met on the northern boundary of the survey box at 2100hr and each vessel ran 2 pre-assigned lines. No additional recordings were made during the survey, except for 1 deviation to record a school of fish along and near the assigned transect. Herring were observed at light and medium densities from the sounder recordings in the upper part of the survey box, with some higher density values located in the central part of the lower half. The survey ended at 0200hr and no fishing took place on the survey night as per prior agreement.

Length frequency samples collected from fishing within the survey box from August 29th to September 7th had comparable length ranges and mean size, which ranged from 281 to 295mm. The proportion greater than 30cm also varied between 5 and 28%. Six samples collected from fishing on the night before this survey were used for the estimation of target strength (Figure 17). The mean size was 285 mm with a range from 22 to 34cm. Almost all fish sampled were larger than 23cm (the mean size at first maturity) and 16% were greater than 30cm (approximately 5-6 years old).

Maturity samples processed by SABS from landings on September 6th-7th showed herring were mostly fully mature with ripe and running gonads. Maturity samples available from industry sources also showed fully mature fish, but had a higher proportion of hard (Stage 5) roe. Biological samples from both industry and SABS sources provided sufficient numbers (152 fish) for the calculation of the length-weight regression used in the estimation of target strength. The TS estimate for a 38/50kHz frequency system of -35.630 differs by only 0.13dB from the standard TS of -35.5 for a 28cm herring used when no samples are available. The increase in mean size and weight changed the TS slightly and increased the SSB by approximately 3% (Table 3).

After the data were downloaded from the 6 boats with FEMTO acoustic recorders, the initial editing for these data was completed by A. Clay. The data for the SIMRAD ES60 system from the *Morning Star* was downloaded by R. Cunningham and editing completed by both G. Melvin and M. Power using the Echoview software package with calibration parameters specific to that vessel.

Seven vessels with recorders completed 14 transects (Figure 15, 16). There was a deviation from one transect to record a school (approximately 800t) close to the line which was considered part of the survey area and was not used further. The Echoview output option for mean area backscatter is equivalent to the HDPS mean Sa in dB/m^2, but only when calculated with the Calibration Integration Factor. As recommended at the Herring Framework review, the standard survey box area of $646km^2$ was used for comparability between years and lines were adjusted to stay within the standard survey box. The biomass estimate using only vessels with FEMTO recording systems for the standard survey box area was 21,600t without the CIF. The biomass estimate using all vessels with recording systems for the standard survey box area was 32.800t with the CIF (Table 6).

German Bank Acoustic Survey #3: September 21, 2007

The third herring acoustic survey of the German Bank spawning area for 2007 took place on the evening of September 21st-22nd using pre-established lines received from SABS staff. Jay Lugar from the Herring Science Council attended and assisted the captains of the purse seine vessels in managing the survey. Nine vessels participated, 7 of which were equipped with acoustic recording gear. The vessels met at the northern boundary of the survey box at 2100hr and each vessel ran 2 pre-assigned lines (Figure 18). No additional recordings were made during the survey. Herring were observed at light and medium densities from the sounder recordings in the upper part of the survey box with some higher density values located in the central and western lower half. The survey ended at 0200hr and no fishing took place on the survey night as per prior agreement.

Four samples collected from fishing on the night before the survey were used in the estimation of target strength (Figure 19). The mean size for these samples was 28.6cm with a range from 23 to 33cm and 15% were greater than 30cm (approximately 5-6 years old). Maturity samples processed by SABS for landings on September 11th-19th showed herring mostly fully mature with ripe and running gonads. Maturity samples available from industry sources from September 10th-21st also showed fully mature fish with an increasing proportion of spawning (Stage 6) roe in the 4 days leading up to the survey night. Biological samples from both industry and SABS sources provided sufficient numbers (215 fish) for the calculation of the length-weight regression used in the estimation of mean weight for target strength. The TS estimate calculated here for a 38/50kHz frequency system of -35.637 differs by only 0.137dB from the standard TS of -35.5 for a 28cm herring used when no samples are available (Table 3).

The data were downloaded from the 6 boats with FEMTO acoustic recorders, and the initial editing for these data was completed by A. Clay. The data for the SIMRAD ES60 system from the *Morning Star* was downloaded by R. Cunningham and editing completed by G. Melvin using the Echoview software package with calibration parameters specific to that vessel. In total, 7 vessels with recorders completed 14 transects with 3 large areas of dense fish recorded across multiple transects (Figure 18). As recommended at the Herring Framework review, the standard survey box area of 646km^2 was used for comparability between years and lines were adjusted to stay within the standard survey box.

The biomass estimate using only FEMTO recording systems for the standard survey box area was 133,800t without the CIF and 178,300t with the CIF. This is the largest single survey estimate for the German Bank area since September 16, 2004, when a biomass of 155,300t was observed (without CIF).

The Echoview output option for mean area backscatter is equivalent to the HDPS mean Sa in dB/m^2 as calculated with the CIF. A final run was completed to provide results for all available survey vessels (*Morning Star* included). In this particular case, the addition of the Simrad data for the *Morning Star* increased the final biomass estimate (with the CIF) for German Bank on September 21st from 178,300 to 191,800t (Table 6).

German Bank Acoustic Survey #4: October 5, 2007

The fourth herring acoustic survey of the German Bank spawning area for 2007 took place on the evening of October 5th using pre-established lines received from SABS staff. Jay Lugar from the Herring Science Council attended and assisted the captains of the purse seine vessels in managing the survey. Seven vessels participated, 5 of which were equipped with acoustic recording gear. The vessels met at the northern boundary of the survey box at 2000hr, and

each vessel ran 2 pre-assigned lines (Figure 20). One main area of fish was observed and recorded on the 'spawn tow' area. There was a school encountered over 4 adjacent lines for a distance of 5 to 8km and the fish were tight on bottom in a layer from 2 to 5m in thickness. Herring were also observed at light and medium densities from the sounder recordings in the central middle and upper western part of the survey box. No additional recordings were made outside of the standard area during the survey. The survey ended at 0100hr and no fishing took place on the survey night as per prior agreement.

Four samples collected from fishing on the nights of October 2nd and October 5th were used in the estimation of target strength (Figure 21). The mean size for these samples was 28.0cm with a range from 23 to 32cm and 8% were greater than 30cm (approximately 5-6 years old). Maturity samples processed by SABS for landings from September 24th-October 5th showed herring mostly fully mature with ripe and running gonads. Maturity samples available from industry sources from September 21st-October 1st also showed mostly fully mature fish with small amounts of spent or hard roe.

Biological samples from both industry and SABS sources provided sufficient numbers (122 fish) for the calculation of the length-weight regression used in the estimation of mean weight for target strength. The TS estimate calculated here for a 38/50kHz frequency system of -35.395 differs by only 0.1dB from the standard TS of -35.5 for a 28cm herring used when no samples are available. The decrease in mean size and weight changed the TS slightly and decreased the SSB by approximately 2%.

The data were downloaded from the 4 boats with FEMTO acoustic recorders, and the initial editing for these data was completed by A. Clay. The data for the SIMRAD ES60 system from the *Morning Star* was downloaded by R. Cunningham and initial editing completed by M. Power using the Echoview software package with calibration parameters specific to that vessel.

Five vessels with recorders completed 10 transects (Figure 8). One large area of dense fish was recorded across multiple (4) transects and an example of the echograms for this school is shown (Figure 9). The fish were very close to bottom in a narrow band and were very difficult to edit. Initial edits were completed by A. Clay and then further edits were made by M. Power while referencing the original echograms.

The density values observed in the layer of fish were calculated using an integration interval of 2 navigation fixes which is the minimum allowed. The maximum number of fish per m^3 observed in the school ranged from 120 to 150 fish, or a total weight of 21 to 26kg/m^3 (with assumptions for a 2m thick layer and an average fish weight of 175g). These are reasonable values in the range of known densities observed for herring over the past.

Problems were encountered when processing the Simrad ES-60 sounder data from the *Morning Star* due to changes in the transmitted pulse length from the calibrated value of 1.024 (ms) to the recorded value of 4.096 (ms). This change in the sounder setting made the data unusable, because the current calibration values for the 1.024 (ms) pulse length could not be applied to this data.

As recommended at the Herring Framework review, the standard survey box area of 646km^2 was used for comparability between years, and lines were adjusted to stay within the standard survey box. The biomass estimate using only FEMTO recording systems for the standard survey box area was 154,000t without the CIF and 228,900t with the CIF (Table 6).

The previous survey on September 21, 2007, was the largest single survey estimate for the German Bank area since September 16, 2004, when a biomass of 155,300t was observed (without CIF). This current survey is nearly equal to that survey in 2004 and is now the second largest survey on German Bank since a fishing night survey of 181,260t was recorded on September 19, 2002.

German Bank Acoustic Survey #5: October 17, 2007

The fifth and final herring acoustic survey of the German Bank spawning area for 2007 took place on the evening of October 17th with the captains of the purse seine vessels managing the survey. Three vessels participated and all were equipped with acoustic recording gear. The vessels met near the northern boundary of the survey box at 1900hr, and each vessel ran randomized lines within the survey box area (Figure 22). Additional recordings were made when areas of fish were encountered during the survey. One area of fish and 3 school areas were observed and recorded south of the 'spawn tow' area with additional lines completed by the survey vessels in this area. The survey ended at 0100hr and no fishing took place on the survey night.

Fishing on German Bank had ended on October 5th due to limitations by a restrictive TAC. The most recent catch locations from landings in October were concentrated in the southwest part of the survey box, while this survey found herring in the southeast area of the survey box. With the lack of a recent fishery or sampling sets during this survey, there were no length frequency or biological samples available to confirm the size or maturity of fish encountered. The TS estimates were thus based on the average size and weight for a 28cm herring adjusted for sounder frequencies (Table 3).

The data were downloaded from the 3 boats with FEMTO acoustic recorders, and the initial editing for these data was completed by A. Clay. Three vessels with recorders completed somewhat random searching lines (Figure 22). One area of fish was recorded in the southeast part of the area. The maximum fish density encountered was much less intense than what was seen in the previous survey on October 7th, and the fish were well clear of the bottom for the most part. However, the purse seine captains on the survey reported that the fish were acting like roe fish, since they went right to the bottom. They also noted they would have normally made a set on them if they had a seine on board, but not all boats had seines and no sets were made.

Estimates were made for the 3 schools alone which varied from 200 to 500t (without CIF) and 300 to 600t (with CIF) for various patterns of survey lines completed in different directions (Figure 23). Two other schools were also recorded by the *Lady Melissa* with estimates of 50 and 400t. Biomass estimates were made using an estimated area of coverage of 320km^2 rather than the total survey area, since the standard protocol of random straight lines was not completed. The final biomass estimate for the October 17th survey was 5,800t without the CIF and 8,100t with the CIF (Table 6). Since the individual schools were within the survey area and are less than these overall estimates, the school estimates were not added to the survey total or used any further.

These estimates are based on standard target strength used when biological samples are not available and are subject to further review as necessary. This was actually a rather poor survey with incomplete coverage of the survey area, poor adherence to survey protocols, with a critical lack of sampling for size and maturity. Given the above factors and associated uncertainty, this survey was not included in the annual total for German Bank. The participants are thanked for

their considerable efforts, but a more structured approach might have produced more reliable/useful results.

German Bank Summary

In summary, the overall spawning stock biomass (without the integration factor) for German Bank in 2007 was estimated to be 337,190t from 4 structured surveys covering a period similar to 2006 survey season extending from August 25th to October 15th, which was about 3 weeks longer than the survey period in 2005 (Table 6). The elapsed time between all surveys was greater than the 10-14 day guideline, and in this analysis, the turnover of spawning fish was assumed to be 100%. The fifth survey of October 17th was not included in the total biomass estimate due to the poor adherence to standard survey protocol and the lack of samples to confirm maturity stage.

As recommended at the RAP herring Framework meeting (January 2007), the use of a standard survey area was applied. This SSB estimate reflects only biomass estimated from within the survey box and may be used in inter-year comparisons for trends. There was an additional 2,800t surveyed in areas close to but outside of the German Bank standard survey area, but this is not included in the overall estimate for German Bank (Table 6). The 2007 estimate of 337,190t represents an 88,700t, or 36% increase, from that observed in 2006. No adjustments were made for possible double counting of fish documented by previously conducted surveys.

Spectacle Buoy

The spring gillnet fishery for roe has occurred in recent years for a short period in June in the vicinity of Spectacle Buoy located just southwest of Yarmouth, Nova Scotia. The fishery is dependent upon the availability of fish and to some extent, market conditions, and may or may not occur in any given year (Table 7). In 2007, a small roe fishery took place with landings of 243t. Three surveys were undertaken between June 11-24, 2007, with a total estimated biomass of 134t from the 2 surveys with at least a 10 day separation (Figure 24, Table 8). The surveys appear to be an afterthought in that the fishery took place earlier and caught more than was observed from acoustic surveys. Fish were believed to have occurred in greater abundance in early June, and it is assumed the surveys missed the majority of fish. No multi-mesh gillnet was used to collect samples and biomass was estimated using the standard TS for a 28cm fish (Table 3).

Trinity Ledge

In previous years, the surveying of spawning herring on Trinity Ledge has been considered to be less than optimal, and it unlikely that biomass estimates accurately reflect the abundance of fish in this area (Power et al. 2006a). Improvements to the survey approach and adherence to the design protocols are required if the data are to reflect trends in abundance.

In 2007, 4 surveys were undertaken between August 28th and September 27th. On each occasion, the single recording vessel documented only a single school of herring near the ledge with biomass estimates ranging from 100 to 2,200t (with the CIF) (Table 9, Figure 25). A multi-panel gillnet was used to collect length frequency and biological sample for TS determination on 2 occasions. The standard protocol for surveys of spawning herring is to allow a minimum of 10 days between surveys in order to avoid double counting of fish that still remain from previous surveys. Summing the survey biomass estimates for the larger nights of August 28th and September 18th, results in a total of 1,360t without the CIF or 3,110t with the CIF for the 2007 season.

These results are considered to provide a reasonable estimate of herring present at the time of surveying. The total biomass of 1,360t represents a sharp decline since 2006, and is one of the lowest recorded since year 2000 (Table 10, Figure 26). Catches were also limited in 2007, but given the marked decline in biomass, the exploitation rate increased from <10% for the past 6 years to 80%. The continued erosion of spawning biomass, despite the restricted fishing on Trinity Ledge, is cause for concern. It is recommended that very limited fishing take place on this spawning ground and that surveys be continued to monitor the status of spawning groups.

Browns Bank

There was no survey activity on Browns Bank in 2007.

Seal Island

Historically, the spawning areas around Seal Island made a significant contribution to the biomass of the Bay of Fundy/SWNS stock complex. In recent years, the abundance of herring and the documentation of spawning fish in this area have been intermittent. In addition, little fishing has occurred in these shallow grounds, partly as a result of the deep purse seines that are now being employed, which are unsuitable for fishing these areas. There was no survey activity in the vicinity of Seal Island in 2007.

Bay of Fundy/SWNS Summary

The 2007 acoustic results are considered to provide a reasonable estimate of herring present at the time of surveying when conducted according to the survey design. A major source of uncertainty continues to be the assumption that the surveys are simply additive. If herring do not move on and off the spawning grounds in waves with a short period of time (days) between the waves, the estimate of total SSB will be significantly biased upward due to double counting. The issue of turn-over time and potential overlap (repeat counting) was evaluated at the RAP Framework review meetings in 2006/2007 (DFO 2007) and the 10-14 day time period between surveys was considered reasonable, but required further investigations.

Since 1997, biomass estimates determined from acoustic surveys have been used to evaluate the status of the Bay of Fundy/SWNS component of the 4WX herring stock complex. During this time, the approach for estimating SSB has evolved from a heavy reliance on distribution and abundance estimates from fishing excursions with a 10 day minimum elapsed time, to structured surveys scheduled at 2-week intervals. In 1999, spawning areas were defined and survey protocols were established to make the estimates more representative of the actual SSB rather than a minimum observed value. This was accomplished by undertaking a series of surveys that covered most of the spawning area on each of the spawning grounds during the defined spawning season.

In the absence of survey data, fishing excursion data may be substituted as appropriate. Regular monitoring of herring gonad development throughout the season, from both industry and DFO sampling, provided evidence that the fish surveyed were mature spawners, and that a turnover of spawning fish had occurred between each survey (and that at least 10 days had elapsed between surveys). The total observed biomass for the complex was obtained by summing the SSB estimate for each spawning ground. Given the changes that have occurred over time the estimated SSB prior to 1999 should not be compared with those reported since that year.

The estimation of biomass from acoustic backscatter relies on the relationship of TS to length measured under a variety of conditions (Foote 1987). The size and weight of herring from appropriate sample data have been applied, but there can still be considerable variance. Studies in controlled conditions in herring weirs (Melvin et al. 2000, 2001) resulted in absolute differences of 7 to 12% between the acoustic estimate and the biomass removed from the weir by seining.

In 2005, the total SSB for the Bay of Fundy/SWNS spawning complex was estimated to be 233,200t, the lowest level observed since acoustic surveys began in 1997 (Table 11). The SSB for Scots Bay was down substantially in 2005, likely due to the excessive catches of 2004 and 2005 (Figure 27). German Bank also had a large decrease in 2005 and estimates of spawning biomass on Spectacle Buoy, Trinity Ledge and Seal Island were low partly due to lack of survey effort.

Since 2005, the total SSB has been gradually increasing with estimates of 286,700t in 2006 and 384,400t in 2007 (Table 11, Figure 28). Scots has shown an improvement over the past couple of years increasing from 16,800 to 45,700t, or 2.7 times, but is still well below the 9 year average of 87,200t. This is the second year in a row an improvement was seen since the low of 16,800t in 2005. German Bank has also increased by 1.7 times and is now just above the average observed between 1999 and 2007. Unfortunately, even with restrictions, there has been an observed decline on Trinity Ledge, and the small amount of biomass around Spectacle Buoy is discouraging. However, the effects of the reduced quotas over the past 3 years now seem to be realized with the increased biomass and the increase in abundance of larger fish on the spawning grounds.

Nova Scotia Coastal Spawning Component

The shallow inshore waters of the bays and inlets along the Atlantic coast of Nova Scotia support a number of herring spawning populations. Several documents describe reports of coastal spawning in 4VWX (Clark et al. 1999; Crawford 1979). Direct knowledge of these relatively small coastal populations is limited to a few areas, where there are active commercial fisheries for roe on spawning grounds. A traditional fishery for lobster bait occurs in the spring and summer of the year. In the fall, commercial roe fisheries were conducted in 3 areas of the Nova Scotia coastal stock component: Port Mouton/Little Hope, Jeddore/Eastern Shore and Glace Bay. Surveys of the spawning grounds were undertaken using both the mapping and the structured acoustic survey approach, depending upon the area and the availability of a recording vessel. The results for each spawning area are presented below.

Acoustic Surveys

Little Hope

The 2007 herring gillnet fishery in the Little Hope/Port Mouton fishing area took place primarily during a 1-week period between October 16-23, 2007, with total landings of 1,506t (Power et al., 2009). The 2007 fishery was unusual in comparison to the previous year in that the fishery was late; most catches were recorded off Liverpool, and there was little herring caught or recorded near Little Hope Island.

Three acoustic surveys were completed in the primary fishing areas near Little Hope/Port Mouton on October 18th, October 21st and November 18th. The data were downloaded from the single boat with an acoustic recorder, the *Knot Paid For*, and after editing to remove bottom and non-herring targets, the acoustic files were cut into transects for each survey. Additional data

were available from deck sheet recordings on October 22nd and November 18th with up to 13 additional vessels participating.

Little Hope Acoustic Survey #1 on October 18, 2007

The first acoustic survey for 2007 was completed by the single acoustic vessel on October 18th, with a total of 9 hours and 115km of surveying around Port Mouton Island and northeast towards Liverpool (Figure 29). Mostly light density targets were recorded except off Liverpool, where a dense herring school was encountered and very well mapped. This school with an area of about 3km^2 was surveyed in 2 directions with 8 equally spaced lines providing excellent coverage for separate biomass estimates. There was no multi-panel sample collected from this survey, and so the samples from the following survey on October 21st were used. Maturity samples from the fishery confirmed that the fish were in spawning condition (Figure 30). Biomass estimates for the school located on October 21st were similar for the 2 passes in different directions with 2,500 and 2,700t recorded as calculated with the CIF (Table 12). Estimates without the CIF were slightly lower at 2,150 and 2,300t (Table 12).

Little Hope Acoustic Survey #2 on October 21, 2007

The second acoustic survey for 2007 took place on October 21st, only 3 days after the previous survey, and was mainly on a school located about 5km northeast of the school location surveyed on October 18th. A total of 11 hours and 145km of surveying was completed by the single acoustic boat with the overall area covered, as well as schools of fish encountered off Liverpool and south of Little Hope Island (Figure 31). The larger group off Liverpool, with an area of about 4km^2, was surveyed in 2 directions with 4 equally spaced lines providing separate biomass estimates. A smaller area south of Little Hope Island was not well defined, and the sounder recordings showed only small groups of thin scattered herring. Surveying of Little Hope Fishing Area was also supplemented by 12 mapping vessels, which observed mostly light density targets but did not locate any other major schools of herring.

A multi-panel gillnet sample with mesh sizes from 1-1/2 to 2-7/8" was used to capture all available sizes and to provide target strength for the acoustic analysis (Table 3). The mean size was 29.9cm with a range from 26 to 34cm (Figure 32). Maturity samples confirmed that the fish were in spawning condition with 88-100% at the spawning (ripe and running) stage during the fishery period (Figure 30). The multi-panel gillnet sample from October 22nd contained 98% ripe and running and 2% spent fish. However, industry supplied roe maturity reports for the same time period showed primarily spawning roe with a mixture of up to 35% spent roe (Figure 33).

Biomass estimates for this survey, when calculated with the CIF, were lower than the previous survey with only 500 to 600t for the 2 passes on the northeast school off Liverpool and an additional 100t found along transects outside of the school for a total of 700t (Table 12). Estimates without the CIF were slightly lower with a total of 600t recorded (Table 12).

Little Hope Acoustic Survey #3 on November 18, 2007

Almost one month had elapsed since the previous survey on October 21st-22nd. A total of 4 hours and 51km of surveying around Port Mouton Island were completed by the single acoustic vessel (Figure 34). There were also 4 non-recording vessels which covered the area east of Port Mouton Island. No significant amounts of fish were encountered except for light scattered fish on the sounder recordings. The multi-panel net was not fished, and there was no fishery or sampling information since October 23rd. Target strength was estimated using standard target

strength values for a 28cm size herring (Table 3). The biomass estimates for this survey were calculated as 60t with the CIF and 50t without the CIF (Table 12).

Little Hope Summary

A total of 3 acoustic surveys were completed in 2007 on October 18th, October 21st and November 18th, with both the schools and the area between schools surveyed. The standard protocol for surveys of spawning herring is to allow 2 weeks between surveys in order to avoid double counting of fish that still remain from previous surveys. Summing the biomass estimates for the 2007 season for the larger night of October 18th and November 18th results in a total of 2,780t with the CIF or 2,390t without the CIF (Table 12).

The total biomass of 2,780t is the lowest recorded since spawning surveys began in 1998, and total catch level approached the total amount surveyed. Given the results, there is concern for the overall lack of fish documented, in particular around Port Mouton Island, rather than the issue of double counting and turnover rates on the spawning grounds. Indications from sampling, with the presence of spent fish, and a fishery which ended just after the second survey, shows that the surveys may have occurred after the peak abundance and that the fish had spawned and were moving away. The other possibility is that there were very few fish around to document.

The fact that no significant amounts of herring were documented near Port Mouton Island over the entire season and that the total biomass surveyed was only slightly more than the amount of catch recorded will likely have a negative impact of recommendations for future catch levels.

Eastern Shore

The 2007 herring gillnet fishery in the Eastern Shore fishing area began on September 25th and ended on November 20th with total landings of 3,727 (Power et al., 2009). This was primarily a herring roe fishery with catches reported from 3 main areas: near Halifax Harbour approaches, southwest of Jeddore Head and south of Ship Harbour, Nova Scotia. The fishery catch and duration was very similar to that of 2006 with daily landings of 150-300t, and most catches recorded by mid October. There was a gap in fishing between October and November 20th, when about 60t were caught and a survey was completed near the Halifax Harbour area.

Surveys were completed in each of the primary fishing areas from Halifax Harbour to near Ship Harbour, Nova Scotia, on October 2nd, October 8th, October 22nd and November 20th (Figure 35). The data were downloaded from the 2 boats with acoustic recorders, *Bradley K* and *Miss Owls Head,* and after editing to remove bottom and non-herring targets, the acoustic files were cut into transects for individual survey. Additional data were examined from deck sheet recordings on October 2nd when 10 vessels participated.

Eastern Shore Acoustic Survey on October 2, 2007

The first acoustic survey for the 2007 season was organized by the Eastern Shore Fishermen's Protective Association (ESFPA) and took place on October 2, 2007, covering an area from the entrance to Halifax Harbour to Jeddore Head. Ten herring gillnet vessels took part including 1 vessel equipped with an acoustic recorder. The acoustic survey boat completed transects on separate schools near Halifax Harbour approaches and southwest of Jeddore Head, as well as covering the area between the schools (Figure 35). Data from visual sounder observations described mostly low to medium density fish. The vessels did not encounter any additional fish

schools other than those surveyed by the acoustic boat. The total aerial coverage for all boats was 75km^2.

The acoustic data were downloaded, edited to remove bottom and non-herring targets and then cut into transects for each area. Lines or transects extracted for the 'Western' , 'Eastern' and 'Southeastern' schools provided good delineation of the spawning aggregations for biomass and area estimation. Lines were also extracted for the area between schools, but little fish was encountered here.

The size in fishery samples using 2-3/4" mesh nets was large with more that 60% by number greater than 30cm. Multi-panel gillnet samples collected from each of the larger schools in the eastern area were similar in size to that seen in the fishery samples. The 3 multi-panel samples from October 2nd-8th were combined and used for the estimation of target strength with an overall mean length of 30.3cm (Figure 36).

Biological samples provided sufficient numbers (72 fish) for the calculation of the length-weight regression used in the estimation of mean weight of 241g for target strength. The TS estimate calculated here for a 120kHz frequency system differs by 0.56dB from the standard TS of -35.9 for a 28cm herring used when no samples are available (Table 3). This increase in mean size and weight changed the TS significantly and increased the SSB by approximately 26%.

Industry supplied roe maturity reports for October 3rd showed primarily spawning roe with a small proportion of hard roe (Figure 37). Samples as processed by SABS technicians were of a similar makeup with about 90% in spawning condition (Figure 38).

Estimates are provided for each of the surveyed schools on October 2nd and for the estimated area between the schools covered by the participating survey vessels. The survey biomass for the 3 schools and the area between the schools is estimated as 22,580t when calculated 'with' the CIF and 16,540t when calculated 'without' the CIF (Table 13).

This was a good survey conducted independently by the fishing vessels involved. The area of coverage reflected where recent herring gillnet catches had occurred and transects on the schools by the acoustic survey boats were well defined, allowing for accurate biomass estimation. Sampling confirmed large spawning herring, and the multi-panel sample data showed a similar size to what was caught in the fishery.

Eastern Shore Acoustic Survey on October 8, 2007

A second acoustic survey took place on October 8, 2007, covering an area near where the (larger) 'Southeastern' school had been surveyed on October 2nd (Figure 35). The fishing captains determined that the spawning school off of Petpeswick had grown larger in area and decided to repeat the survey on the single school. Two gillnet vessels took part including 1 (*Miss Owls Head*), which used an acoustic recorder, and a second vessel (Bradley K), which collected a multi-panel gillnet sample.

The herring were in found in an area with bottom depths of 25 fathoms spread out over a large area and moving around, but not considered overly dense. The fish were seen gathering up in the daytime in shoaler water where they tend to spawn, and the location overlapped the same area which was surveyed 6 days previously. Density estimates were calculated as number of fish per square meter and number per cubic meter using an average fish weight of 250g and school thickness of 10m. The fish were considerably denser during the first survey on October 2nd with maximum average density for a single transect as high as 26kg/m^2 (100 fish/m^2

or 10 fish/m^3) as compared to maximum values of 16 kg/m^2 (65 fish/m^2 or 6 fish/m^3) for the October 8th survey.

The biomass estimate for the single school surveyed on October 8th was 17,475t when calculated 'with' the CIF and 15,500t when calculated 'without' the CIF (Table 3). This was slightly more (by 870t) than the 16,600t, which was observed on October 2nd for the southeastern school, and will be used to replace this amount in the final overall estimate for the entire Eastern Shore area.

Eastern Shore Acoustic Surveys on October 18-22, 2007

Acoustic surveys took place on October 18th, October 19th and October 22nd, covering an area from Owls Head to Jeddore, but very few herring were found except near the Inner Pollock shoal area (Figure 35). When fish were encountered, the school was recorded with a pattern of parallel lines which was also done in 2 separate directions (east to west or north to south) when sufficient amounts were present. There was no multi-panel gillnet sample collected because the net did not fish properly or catch any fish. The target strength estimate calculated for the October 2nd-8th survey was used in its place.

The biomass estimate for the 7 schools surveyed summed together from October 18th-22nd is 4,300t when calculated 'with' the CIF and 3,800t when calculated 'without' the CIF (Table 4). These sums use the maximum amount estimated for multiple passes were made on the same school.

Eastern Shore Acoustic Survey on November 21, 2007

A final acoustic survey took place on November 21, 2007, covering a small spawning school located off Eastern Passage in the Halifax Harbour approaches area (Figure 35). A number of passes were made over the single school in different directions and estimates were then calculated. A multi-panel sample was used to collect herring for size and maturity (Figure 39). The sample had a mean length of 29.4cm and the resulting TS of -36.3 differs by 0.4dB from the standard TS used when no samples are available (Table 3). The maximum biomass estimate for the single school surveyed on November 21st is 540t as calculated 'with' the CIF and 400t when calculated 'without' the CIF (Table 13).

Summary

The total spawning biomass for the Eastern Shore area is taken as the sum of the October 2nd, October 18th-22nd and November 21st surveys with substitution of a larger estimate for a school repeated on October 8th (Table 13). The overall estimates are 28,280t with the CIF and 24,040t without the CIF.

Summary of Eastern Shore Survey Results

Despite the effort put into finding herring and the coverage of surveys, the estimated SSB for the Eastern Shore area declined substantially (53%) in 2007 (Table 13) The total spawning biomass for the Eastern Shore area was taken as the sum of the October 2nd, October 18th-22nd and November 21st surveys with substitution of a larger estimate for a school repeated on October 8th (Table 13). The overall estimates are 28,280t with the CIF and 24,040t without the CIF. A multi-panel gillnet was used to collect a representative sample of herring being surveyed on October 2nd, October 8th and November 20th.

As with the other surveys, a major concern or source of uncertainty is the assumption that the surveys are simply cumulative. If herring do not move 'on to' and 'off of' the spawning grounds in waves, the estimate of total SSB will be significantly biased upward due to double counting. Another major issue, which was addressed at the 2007 Herring Framework review, is the use of these estimates as absolute measures of biomass due to the many uncertainties with target strength.

Glace Bay

Three herring acoustic surveys were conducted in 2007 near Glace Bay, Nova Scotia, by a single survey vessel (*Natasha Lee)*. There was no herring roe fishery in 2007 with only 5t reported and, thus, no industry input in defining possible search areas for surveying in this area.

There were problems in processing the raw data due to numerous errors in the navigation fixes. These were removed using the interactive routines in the HDPS acoustic software. It was recommended that the GPS system be upgraded to a more reliable unit for future surveys.

No length frequency samples were available from the few landings to determine the overall survey mean length and the calculation of target strength. A sample from a multi-panel net with various mesh sizes is required to properly estimate the total size range of herring surveyed, but this was not available. As a result, the standard target strength value for a 28cm herring was used with an adjustment for the sounder frequency of 120kHz.

On September 14, 2007, the single survey vessel searched the Red Grounds area with a series of 6 equally spaced transects through the area (Figure 40). The acoustic data was then divided into transects which showed an aerial coverage of 12km^2 (Table 14). The biomass estimate for this survey was calculated as 220t with the CIF and 100t without the CIF (Table 14).

Additional survey nights were completed on October 4th and October 14th with searching taking place just north of Glace Bay, but weather conditions were not suitable and there was no grid pattern of survey lines. Biomass estimates for these 2 days were minimal with less than 10t calculated for each night (Table 14).

The overall biomass estimate (taken as the sum of the surveys) is 240t with the CIF and 110t without the CIF. These estimates are based on standard target strength with adjustment for sounder frequency and are subject to further review as necessary.

Bras d'Or Lakes

No surveys were conducted in 2007 to document the abundance of spawning herring and no biological data were collected in the Bras d'Or Lakes. The last mapping survey was conducted in 2000 and documented only 70t.

Summary for Nova Scotia Coastal Component

The 2007 landings of 5,240t from the 4 major gillnet fisheries along the coast of Nova Scotia declined by a little more than 1,300t, mostly from the Little Hope/Port Mouton area (Table 15). Catches increased slightly for the Eastern Shore area due to an increase in allocation, but Glace Bay fishery was essentially non existent and the Bras d'Or Lakes fishery remained closed (Table 15, Figure 41).

The acoustic biomass estimates for all survey areas declined substantially in 2007. The documented biomass around Little Hope/Port Mouton dropped dramatically from 21,700t in 2006 to 2,400t in 2007. Eastern Passage SSB also declined by approximately 50% from 51,000 to 24,000t. The Glace Bay area surveys documented only 100t (Table 15, Figure 41).

As indicated for the SWNS/Bay of Fundy component, summing of multiple surveys may result in overestimates of SSB due to double counting. However, the majority of surveys of the coastal Nova Scotia spawning component were undertaken on spatially separated aggregations of fish.

Offshore Scotian Shelf Component

Fleet activity/catch in the spring/early summer fishery on the offshore banks of the Scotian Shelf has varied between 1,000 and 20,000t since 1996 with landings of 5,263t in 2005. Acoustic recorders were activated on a few occasions, but insufficient quantities of fish were observed to warrant analysis. Consequently, no acoustic biomass estimates were available from the Scotian Shelf. There was again no fall herring research survey on the Scotian Shelf using the research vessel *CCGS Alfred Needler*.

No acoustic surveys were undertaken on the outer Scotian Shelf banks in 2007.

DISCUSSION

The spawning stock biomass for the Bay of Fundy/SWNS component of the 4WX herring stock complex in 2007 was determined from industry based acoustic surveys of the 3 major spawning components: Scots Bay, Trinity Ledge and German Bank. No structured surveys were conducted outside the main spawning areas, around Seal Island or in the vicinity of Browns Bank. Acoustic data from several fishing night were analyzed and reviewed, but were not included in the biomass estimate for any spawning component. Fishing and survey activity in the Spectacle Buoy area was limited with few fish observed during the surveys.

This is the eleventh year of surveying in which biomass estimates from industry based surveys have played a significant role in the evaluation of the 4WX herring stock abundance. For 2007, the majority of acoustic surveys in the Bay of Fundy/SWNS areas were well organized and provided good coverage of the spawning grounds. The survey vessels generally completed the assigned transects, and automated recording systems were distributed throughout the fleet on survey nights. The set of surveys for the overall areas are considered to be comparable to others in the series since 1999.

In 2005, the observed SSB for Scots Bay decreased dramatically to only 16,800t, which was the lowest recorded for the component (Table 11). The Scots Bay acoustic survey SSB estimated from the structured surveys increased in 2006 and again in 2007 to around 45,700t. While this is an improvement over the 2005 and 2006 estimates, the SSB remains low in this area, and it is well below (50%) the 1999-2007 average of 87,200t.

Coverage of Trinity Ledge in 2007 was much improved over the last few years, with an increased number of surveys completed and an increased area of coverage. The single recording vessel tended to concentrate on a relatively small area where the schools of fish were located, but structured multi-vessel surveys covering the entire spawning strata area of 100km^2 were also conducted on 2 occasions. The reduced biomass and increased catches in 2007 around the Trinity Ledge survey area is cause for concern and suggests this spawning component is not improving. Catches amounted to almost 80% of what was observed in the

surveys. Trinity Ledge once supported a large spawning component within the 4WX stock complex. As such, given the fact that the observed biomass is still reduced, any fishing on Trinity Ledge must strictly adhere to the "survey, assess, then fish" protocol during the upcoming spawning season. This means that no fishing should occur until sufficient quantities of herring are observed to allow for removals. Alternatively, given the slow rate of recovery, consideration should also be given to complete closure until a significant increase in spawning biomass is observed.

In 2005, the total spawning stock biomass observed on German Bank was one of the lowest recorded for this area at 211,000t, a decrease of 150,000t from 2004, and well below the average (Table 11). The SSB in 2005 was based on estimates of biomass from only 3 structured surveys undertaken from September 7th to October 4th. In 2006, the overall spawning biomass for German Bank was 245,500t from 4 structured surveys representing a 16% increase from that observed in 2005.

In 2007, the overall spawning stock biomass for German Bank was estimated at 337,200t from 4 structured surveys (Table 6) extending from August 24th to October 17th, which was similar to the survey period in 2006. This represents a significant increase over the past 2 years; a 60% increase since 2005 and a 37% increase from 2006. The elapsed time between all surveys was within the 10-14 day guideline and turnover of spawning herring was assumed to be 100% for this analysis. Another positive sign is that the overall mean size of spawning fish has also increased.

Biomass estimates for the Nova Scotia coastal spawning component of the 4WX stock complex included acoustic and mapping survey data from Little Hope/Port Mouton, the Halifax/Eastern Shore and Glace Bay areas. The 2007 biomass estimates showed a large and concerning decline in all areas surveyed. The decrease was significant and represented about a 50% in Eastern Passage and 90% in Little Hope area. Reasons for the decline are unknown, but caution should be used when establishing catch levels for these spawning areas. The first survey in 2 years in the Glace Bay area was completed in 2007, but very few fish were documented. Caution is also warranted in this area when setting catch levels for 2008.

No biomass estimates were made for the Bras d'Or Lakes or for the offshore Scotian Shelf banks. Large winter aggregations of herring off Chebucto Head have not been documented since January 2002. No acoustic surveys were undertaken in Southwest New Brunswick during 2007.

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Table 1. Summary of the number of surveys scheduled and number undertaken in 2007 with the number of fishing nights examined in the estimation of spawning stock biomass in the 4VWX stock and coastal component complexes.

Spawning Ground	Surveys Scheduled	Surveys Completed	Fishing Nights
Scots Bay	3	4	0
German Bank	3	5	7
Spectacle Buoy	2	3	0
Trinity Ledge	2	4	0
Browns Bank	0	0	0
Seal Island	0	0	0
Little Hope	2	3	0
Eastern Shore	2	4	0
Glace Bay	2	3	0
Total	16	26	7

Table 2. Summary of completed herring acoustic surveys undertaken in 2007 with interval (days) between surveys on the same grounds, number of boats with acoustic systems and the number of mapping boats (without acoustic systems using deck sheets only).

Survey Date	Location of survey	Interval (days)	Acoutic Boats	Mapping Boats	Total No. Boats
14-Jul-07	Scots Bay #1	0	3	0	3
28-Jul-07	Scots Bay #2	14	4	0	4
11-Aug-07	Scots Bay #3	13	4	1	5
24-Aug-07	Scots Bay #4	13	4	0	4
24-Aug-07	German Bank #1	0	5	4	9
07-Sep-07	German Bank #2	13	7	3	10
21-Sep-07	German Bank #3	14	7	2	9
05-Oct-07	German Bank #4	14	5	2	7
17-Oct-07	German Bank #5	12	3	0	3
11-Jun-07	Spectacle Buoy #1	0	1	0	1
12-Jun-07	Spectacle Buoy #2	1	1	0	1
24-Jun-07	Spectacle Buoy #3	12	1	2	3
28-Aug-07	Trinity Ledge #1	0	1	0	1
31-Aug-07	Trinity Ledge #2	3	1	16	17
18-Sep-07	Trinity Ledge #3	18	1	18	19
27-Sep-07	Trinity Ledge #4	9	1	0	1
18-Oct-07	Little Hope #1	0	1	0	1
21-Oct-07	Little Hope #2	3	1	12	13
18-Nov-07	Little Hope #3	27	1	3	4
02-Oct-07	Eastern Shore #1	0	1	9	10
08-Oct-07	Eastern Shore #2	6	2	0	2
18-Oct-07	Eastern Shore #3	10	2	0	2
21-Nov-07	Eastern Shore #4	33	1	0	1
14-Sep-07	Glace Bay #1	0	1	0	1
04-Oct-07	Glace Bay #2	20	1	0	1
14-Oct-07	Glace Bay #3	10	1	0	1
Total number of survey boat nights			61	72	133

Table 3. Summary of fish sampled by survey date and location with target strength estimate from samples, and target strength estimate for a 28cm herring using the length/weight equation.

Date of Survey	Location of survey	Interval (days)	Number Samples	Number Measured Fish	Number Len/Wt Fish	Mean Length (mm)	Mean Weight (gm)	Target Strength dB/kg [1]	Wt 28 cm Fish (gm)	TS 28 cm Fish dB/kg [1]
14-Jul-07	Scots Bay #1	0	3	459	60	280	187	-35.664	186	-35.658
28-Jul-07	Scots Bay #2	14	2	238	107	271	160	-35.275	179	-35.478
11-Aug-07	Scots Bay #3	13	3	386	119	276	168	-35.319	175	-35.393
24-Aug-07	Scots Bay #4	13	3	341	35	276	175	-35.525	185	-35.631
24-Aug-07	German Bank #1	0	4	517	399	292	207	-35.768	181	-35.524
07-Sep-07	German Bank #2	13	6	690	152	285	192	-35.630	181	-35.522
21-Sep-07	German Bank #3	14	4	514	215	286	194	-35.637	180	-35.502
05-Oct-07	German Bank #4	14	4	543	122	280	175	-35.395	176	-35.400
17-Oct-07	German Bank #5	12	0	0	0					-35.500
11-Jun-07	Spectacle Buoy #1	0	0							-35.949
12-Jun-07	Spectacle Buoy #2	1	0							-35.949
24-Jun-07	Spectacle Buoy #3	12	0							-35.949
28-Aug-07	Trinity Ledge #1	0	0							-35.949
31-Aug-07	Trinity Ledge #2	3	1	140	33	266	159	-35.871	187	-35.949
18-Sep-07	Trinity Ledge #3	18	0							-35.949
27-Sep-07	Trinity Ledge #4	9	1	154	50	275	169	-35.857	180	-35.949
18-Oct-07	Little Hope #1	0	0							-35.949
21-Oct-07	Little Hope #2	3	1	303	132	299	221	-36.282	181	-35.949
18-Nov-07	Little Hope #3	27	0							-35.949
02-Oct-07	Eastern Shore #1	0	1	289	72	304	241	-36.509	195	-35.949
08-Oct-07	Eastern Shore #2	6	0							-35.949
18-Oct-07	Eastern Shore #3	10	0							-35.949
21-Nov-07	Eastern Shore #4	33	0	1	94	294	215	-36.301	187	-35.949
14-Sep-07	Glace Bay #1	0	0							-35.949
04-Oct-07	Glace Bay #2	20	0							-35.949
14-Oct-07	Glace Bay #3	10	0							-35.949

[1] TS adjusted by -0.26575 and -0.44946 dB to account for difference in acoustic signal for 75 and 120 kHz systems. No adjustment for 50kHz systems.

Table 4. Summary of the 2007 herring biomass estimates observed during fishing nights for various grounds off SWNS and the Bay of Fundy. Standard target strength and calculation without the CIF were used.

No	Date	Vessels	Ground	Total Area (km2)	TS	Mean Density (kg/m2)	Mean of strata Sa (dB re /m2)	Strata Biomass (tons)
1	22-Aug-07	IP, L&B	German	22.00	-35.5	0.1870	-42.780	4,116
2	5-Sep-07	IP, LJ, L&B, LM	German	35.00	-35.5	0.4836	-38.655	16,927
3	9-Sep-07	LJ, L&B, LM	German	10.00	-35.5	1.3080	-34.333	13,083
4	11-Sep-07	IP, LJ, L&B, LM	German	6.00	-35.5	2.5126	-31.499	15,100
5	13-Sep-07	Lady Melissa	German	1.40	-35.5	2.3776	-31.739	3,329
6	18-Sep-07	Leroy&Barry	German	4.00	-35.5	7.5200	-26.735	29,345
7	19-Sep-07	Morning Star	German	10.00	-35.5	4.7670	-28.717	47,674
Vessel names: IP - Island Pride, LJ - Lady Janice, L&B, Leroy & Barry, LM - Lady Melissa								

Table 5. Summary of the 2007 Scots Bay spawning ground acoustic survey data and associated biomass estimates for the standard survey box area (inbox) and for outside the survey box (outbox). The total SSB for the spawning component was obtained for each grouping by summing the biomass estimates.

a - without integration factor; as presented since 1997

Location/ Type	Date	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Scots Bay (inbox)	14-Jul-07	-35.80	636	-54.65	0.013	8,027	5,533	69%
	28-Jul-07	-35.50	636	-48.90	0.046	29,240	26,172	90%
	11-Aug-07	-35.45	636	-55.17	0.010	6,584	4,528	69%
	24-Aug-07	-35.60	636	-60.97	0.003	1,845	588	32%
Scots Bay total for standard survey area (inbox)						45,697	27,137	59%
Scots Bay (outbox)	14-Jul-07	-35.90	110	-63.80	0.002	181	157	87%
	28-Jul-07					0		
	11-Aug-07	-35.60	20	-49.58	0.040	797	604	76%
	24-Aug-07	-35.60	3.53	-38.92	0.894	1,003	163	16%
Scots Bay total for non-standard survey area (outbox)						1,981	645	33%

b - with integration factor as introduced in 2004 assessment

Location/ Type	Date	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Scots Bay	14-Jul-07	-35.80	636	-54.31	0.014	8,680	6,026	69%
	28-Jul-07	-35.50	636	-48.52	0.050	31,962	28,551	89%
	11-Aug-07	-35.45	636	-54.40	0.012	7,867	4,093	52%
	24-Aug-07	-35.60	636	-60.73	0.003	1,953	601	31%
Scots Bay total for standard survey area (inbox)						50,461	29,472	58%
Scots Bay (outbox)	14-Jul-07	-35.90	110	-62.90	0.002	219	191	87%
	28-Jul-07					0		
	11-Aug-07	-35.60	20	-48.87	0.047	939	736	78%
	24-Aug-07	-35.60	3.53	-38.58	0.950	1,079	181	17%
Scots Bay total for non-standard survey area (outbox)						2,237	782	35%

Table 6. Summary of the 2007 German Bank spawning ground acoustic survey results and SSB biomass estimates.

a - without integration factor; as presented since 1997

Location/ Type	Date	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
German Bank (inbox)	24-Aug-07	-35.90	646	-49.56	0.043	27,852	3,154	11%
	07-Sep-07	-35.70	646	-50.44	0.034	21,622	5,796	27%
	21-Sep-07	-35.70	646	-42.51	0.207	133,763	48,606	36%
	05-Oct-07	-35.40	646	-41.63	0.238	153,955	75,772	49%
	17-Oct-07	-35.60	320	-52.99	0.018	5,814	3,526	61%
German Bank inbox total (excludes Oct. 17 survey)						337,192	90,263	27%
German Bank (outbox)	24-Aug-07	-35.90	50	-48.43	0.056	2,820	1,145	41%
	07-Sep-07					0		
	21-Sep-07					0		
	05-Oct-07					0		
	17-Oct-07					0		
German Bank outbox total						2,820	1,145	41%

b - with integration factor as introduced in 2004 assessment

Location/ Type	Date	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
German Bank	24-Aug-07	-35.90	646	-47.64	0.065	41,965	3,638	9%
	07-Sep-07	-35.76	646	-48.58	0.051	32,769	8,406	26%
	21-Sep-07	-35.77	646	-40.91	0.297	191,802	61,678	32%
	05-Oct-07	-35.40	646	-39.91	0.354	228,870	113,376	50%
	17-Oct-07	-35.60	320	-51.57	0.025	8,064	4,890	61%
German Bank total (excludes Oct. 17 survey)						495,406	129,392	26%
German Bank (outbox)	24-Aug-07	-35.90	50	-46.96	0.079	3,955	1,607	41%
	07-Sep-07					0		
	21-Sep-07					0		
	05-Oct-07					0		
	17-Oct-07					0		
German Bank outbox total						3,955	1,607	41%

Table 7. Catch and survey history for the Spectacle Buoy spring herring fishery from 1999 to 2007.

Year	Catch (t)	Survey SSB (t)	Notes
1999	355	n/a	Poor weather and fish left before survey completed
2000	80	n/a	No survey
2001	699	1110	3 surveys completed
2002	137	n/a	No survey
2003	69	1416	2 surveys completed on June 2 & 4.
2004	0	n/a	No fishery or survey
2005	124	292	1 survey on June 6
2006	2	n/a	No survey
2007	243	310	3 surveys but after peak abundance

Table 8. Biomass estimation for the 2007 Spectacle Buoy acoustic surveys. The shaded boxes represent the biomass estimates summed for the overall SSB based on the 10-14 day time window between surveys.

a - without integration factor: as presented since 1997

Location/ Type	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Spectacle Buoy	11-Jun-07	280	-35.9	0.2	-38.5	0.552	127	29	23%
	12-Jun-07	280	-35.9	0.1	-34.4	1.438	122	39	32%
	24-Jun-07	280	-35.9	1.0	-57.6	0.007	7	3	16%
Spectacle Buoy total (includes June 11 and June 24)							134	29	22%

b - with integration factor as introduced in 2004 assessment

Location/ Type	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Spectacle Buoy	11-Jun-07	280	-35.9	0.2	-34.9	1.267	291	67	23%
	12-Jun-07	280	-35.9	0.1	-30.8	3.299	280	91	33%
	24-Jun-07	280	-35.9	1.0	-53.9	0.016	16	8	16%
Spectacle Buoy total (includes June 11 and June 24)							307	67	22%

Table 9. Biomass estimation for the 2007 Trinity Ledge acoustic surveys. The shaded boxes represent the biomass estimates summed for the overall SSB based on the 10-14 day time window between surveys.

a - without integration factor; as presented since 1997

Location/ Type	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Trinity Ledge	Aug. 28	266	-35.9	0.2	-32.8	2.006	401	155	39%
	Aug. 31	266	-35.9	0.1	-30.0	3.907	234	85	36%
	Sept. 18	275	-35.9	0.4	-32.1	2.390	956	247	16%
	Sept. 27	280	-35.5	3.3	-50.7	0.030	100	43	43%
Trinity Ledge total (includes Aug. 28 and Sept. 18)							1,357	292	21%

b - with integration factor (as calculated since 2003)

Location/ Type	Date	Mean Length (mm)	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Trinity Ledge	Aug. 28	266	-35.9	0.2	-29.2	4.600	920	357	39%
	Aug. 31	266	-35.9	0.1	-26.3	8.961	538	194	36%
	Sept. 18	275	-35.9	0.4	-28.5	5.482	2,193	567	16%
	Sept. 27	280	-35.5	3.3	-50.6	0.031	102	44	43%
Trinity Ledge total (includes Aug. 28 and Sept. 18)							3,113	670	22%

Table 10. Catch and survey history for the Trinity Ledge herring fishery.

Fishery Start Day	Fishery End Day	Catch t	Survey Biomass t	Exploitation Catch/SSB
24-Aug-98	21-Sep-98	1,668.10		
12-Aug-99	15-Sep-99	1,256.59	3,885	32%
30-Aug-00	12-Sep-00	733.62	621	118%
21-Aug-01	26-Sep-01	1,012.35	14,797	7%
02-Sep-02	30-Sep-02	255.77	8,096	3%
21-Aug-03	18-Sep-03	369.31	14,512	3%
02-Sep-04	15-Sep-04	224.71	6,511	3%
05-Sep-05	20-Sep-05	446.62	5,071	9%
23-Aug-06	21-Sep-06	716.68	8,486	8%
27-Aug-07	20-Sep-07	1,090.95	1,357	80%
Average		777.5	7,037.3	11%

Table 11. Summary of the minimum observed spawning stock biomass for each of the surveyed spawning grounds in the Bay of Fundy/SWNS component of the 4WX stock complex. Total SSB rounded to nearest 100t and all data calculated without the integration calibration factor.

Location/Year	1997*	1998*	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average 1999-2007
Scots Bay	160,200	72,500	41,000	106,300	163,900	141,000	133,900	107,600	16,800	28,600	45,700	87,200
Trinity Ledge	23,000	6,800	3,900	600	14,800	8,100	14,500	6,500	5,100	8,500	1,400	7,044
German Bank (in)	370,400	440,700	460,800	356,400	190,500	393,100	343,500	367,600	211,000	245,500	337,200	322,844
- German (out)										4,100		4,100
Spectacle Buoy												
- Spring	15,000	1,300	0	0	1,100		1,400	n/s	300	n/s	100	483
- Fall					87,500					0	0	29,167
Sub-Total	568,600	521,300	505,700	463,300	457,800	542,200	493,300	481,700	233,200	286,700	384,400	427,589
Seal Island					3,300	1,200	12,200			8,100		6,200
Browns Bank					45,800					6,100		25,950
Total	568,600	521,300	505,700	463,300	506,900	543,400	505,400	481,700	233,200	300,900	384,400	436,100
Overall SE t	n/a	n/a	94,600	64,900	50,800	49,500	86,100	74,200	64,900	47,251	94,255	69,612
Overall SE %	n/a	n/a	19	14	10	9	17	15	28	16	25	17

*Biomass estimates prior to 1999 are not considered comparable due to variation in the coverage area.

Table 12. Biomass estimation for the 2007 Little Hope/Port Mouton acoustic surveys. The shaded boxes represent the biomass estimates summed for the overall SSB based on the 10-14 day time window between surveys.

a - without integration factor; as presented since 1997

Location/ Type	Date	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Little Hope	18-Oct-07	-36.3	2.9	-37.2	0.806	2,337	1,331	57%
	21-Oct-07	-36.3	3.1	-44.7	0.227	614	478	78%
	18-Nov-07	-35.9	4.0	-55.7	0.011	54	32	59%
Little Hope total (includes Sept. 18 and Nov. 18)						2,391	1,414	59%

b - with integration factor (as calculated since 2003)

Location/ Type	Date	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Little Hope	18-Oct-07	-36.3	2.9	-36.6	0.937	2,718	1,548	57%
	21-Oct-07	-36.3	3.1	-44.1	0.264	714	556	78%
	18-Nov-07	-35.9	4.0	-55.1	0.012	63	37	58%
Little Hope total (includes Sept. 18 and Nov. 18)						2,781	1,645	59%

Table 13a. Biomass estimation for the 2007 Halifax/Eastern Shore acoustic surveys as calculated without the CIF. The shaded boxes represent the biomass estimates summed for the overall SSB based on the 10-14 day time window between surveys.

a - without integration factor; as presented since 1997

Survey Date	Stratum	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Oct. 2, 2007	Western_school	-36.5	9.0	-44.87	0.146	1,311	469	36%
Oct. 2, 2007	Between_schools	-36.5	10.0	-50.16	0.043	431	162	37%
Oct. 2, 2007	Eastern_school	-36.5	0.8	-31.49	3.178	2,638	1,109	42%
Oct. 2, 2007	Southeastern_school	-36.5	1.3	-26.66	9.652	12,162	3,637	30%
Oct. 8, 2007	Se_school_oct8	-36.5	1.8	-27.04	8.850	15,487	3,657	24%
Oct.18, 2007	Oct18_bk_school1	-36.3	0.07	-42.48	0.241	17	14	84%
Oct.18, 2007	Oct18_bk_school2	-36.3	0.69	-44.36	0.156	108	53	49%
Oct.18, 2007	Oct18_bk_school3	-36.3	0.40	-1020.56	0.000	-	0	1%
Oct.19, 2007	Oct19_moh_school4	-36.3	0.26	-29.84	4.430	1,152	177	15%
Oct.19, 2007	Oct19_moh_school5	-36.3	0.03	-32.10	2.634	79	31	39%
Oct.22, 2007	Oct22_bk_east_west	-36.3	0.48	-36.99	0.854	410	202	49%
Oct.22, 2007	Oct22_moh_east_west	-36.3	0.31	-30.45	3.843	1,191	433	36%
Oct.22, 2007	Oct22_bk_north_south	-36.3	0.30	-34.53	1.505	452	403	89%
Oct.22, 2007	Oct22_moh_north_south	-36.3	0.29	-30.04	4.224	1,225	774	63%
Nov. 21, 2007	East_pass_nov21_run1	-36.3	0.14	-32.07	2.648	371	159	43%
Nov. 21, 2007	East_pass_nov21_outer	-36.3	0.36	-74.82	0.000	0	0	74%
Nov. 21, 2007	East_pass_nov21_run2	-36.3	0.06	-27.72	7.212	397	134	34%
Nov. 21, 2007	East_pass_nov21_run3	-36.3	0.04	-26.51	9.531	405	51	13%
Overall	**Calculated without CIF**					**24,044**	**3,959**	**16%**

Table 13b. Biomass estimation for the 2007 Halifax/Eastern Shore acoustic surveys as calculated with the CIF.

b - with integration factor (as calculated since 2003)

Survey Date	Stratum	Average TS (dB/kg)	Stratum Area (km2)	Weighted Mean Sa (/m2)	Biomass Density (kg/m2)	Strata Biomass (tons)	Standard Error (tons)	Standard Error (%)
Oct. 2, 2007	Western_school	-36.5	9.0	-43.52	0.199	1,790	641	36%
Oct. 2, 2007	Between_schools	-36.5	10.0	-48.81	0.059	589	221	37%
Oct. 2, 2007	Eastern_school	-36.5	0.8	-30.14	4.339	3,601	1,514	42%
Oct. 2, 2007	Southeastern_school	-36.5	1.3	-25.31	13.176	16,602	4,964	30%
Oct. 8, 2007	Se_school_oct8	-36.5	1.8	-26.52	9.986	17,475	4,127	24%
Oct.18, 2007	Oct18_bk_school1	-36.3	0.07	-41.13	0.329	23	19	84%
Oct.18, 2007	Oct18_bk_school2	-36.3	0.69	-43.01	0.214	147	72	49%
Oct.18, 2007	Oct18_bk_school3	-36.3	0.40	-1020.56	0.000	-	0	1%
Oct.19, 2007	Oct19_moh_school4	-36.3	0.26	-29.31	4.999	1,300	199	15%
Oct.19, 2007	Oct19_moh_school5	-36.3	0.03	-31.57	2.972	89	35	39%
Oct.22, 2007	Oct22_bk_east_west	-36.3	0.48	-35.64	1.166	559	276	49%
Oct.22, 2007	Oct22_moh_east_west	-36.3	0.31	-29.93	4.337	1,344	489	36%
Oct.22, 2007	Oct22_bk_north_south	-36.3	0.30	-33.17	2.055	616	551	89%
Oct.22, 2007	Oct22_moh_north_south	-36.3	0.29	-29.52	4.766	1,382	874	63%
Nov. 21, 2007	East_pass_nov21_run1	-36.3	0.14	-30.79	3.558	498	209	42%
Nov. 21, 2007	East_pass_nov21_outer	-36.3	0.36	-73.71	0.000	0	0	75%
Nov. 21, 2007	East_pass_nov21_run2	-36.3	0.06	-38.45	0.609	34	161	481%
Nov. 21, 2007	East_pass_nov21_run3	-36.3	0.04	-25.23	12.801	544	63	12%
Overall	**Calculated with CIF**					**28,284**	**4,565**	**16%**

Table 14. Summary of the 2007 Glace Bay acoustic surveys with biomass results calculated both without the CIF and with the CIF.

a - without integration factor; as presented since 1997

Location/ Type	Date	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Glace Bay	14-Sep-07	-35.9	12.0	-56.6	0.009	104	64	62
	4-Oct-07	-35.9	5.0	-67.7	0.001	3	1	18
	14-Oct-07	-35.9	5.0	-79.0	0.000	0	0	60
Glace Bay total						104	64	62%

b - with integration factor (as calculated since 2003)

Location/ Type	Date	Target Strength (dB/kg)	Area (km^2)	Weighted Sa (dB/m^2)	Density (kg/m^2)	Biomass (t)	Standard Error (t)	SE %
Glace Bay	14-Sep-07	-35.9	12.0	-53.2	0.019	228	141	62
	4-Oct-07	-35.9	5.0	-64.3	0.002	7	1	18
	14-Oct-07	-35.9	5.0	-75.6	0.000	1	0	60
Glace Bay total						236	141	60%

Table 15. Summary of landings (t) and acoustic survey biomass (t) for the Nova Scotia coastal spawning component spawning areas from 1996 to 2007. Acoustic survey estimates of SSB are rounded to the nearest 100t.

a - Landings by spawning area along coastal Nova Scotia with 5 year and overall averages

Landings (t)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average Catch Last 5 yr.	Average Catch All Years
Little Hope/Port Mouton		490	1,170	2,919	2,043	2,904	3,982	4,526	1,267	2,239	3,133	1,506	2,534	2,380
Halifax/Eastern Shore	1,280	1,520	1,100	1,628	1,350	1,898	3,334	2,727	4,176	3,446	3,348	3,727	3,485	2,461
Glace Bay		170	1,730	1,040	834	1,204	3,058	1,905	1,481	626	85	7	821	1,104
Bras d'Or Lakes	170	160	120	31	56	0	1	4	0	0	0	0	1	45
Total	1,450	2,340	4,120	5,618	4,283	6,006	10,375	9,162	6,924	6,311	6,566	5,240	7,430	5,700

b - Acoustic survey biomass by spawning area along coastal Nova Scotia with 5 year and overall averages (without CIF)

Survey SSB (t) w/o CIF	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	10% SSB Average Last 5 yr	10% SSB Average All years
Little Hope/Port Mouton	**14,100**	15,800	5,200	21,300	56,000	**62,500**	15,600	39,500	21,700	2,400	2,834	2,541
Halifax/Eastern Shore	8,300	20,200	**10,900**	16,700	**41,500**	67,602	18,200	28,100	51,100	24,000	3,780	2,866
Glace Bay		2,000		21,200	7,700	31,500		2,200	n/s	100	1,127	1,078
Bras d'Or Lakes		530	70	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	30

Note: shaded cells include mapping surveys; bold cells include mapping and acoustic surveys.

c - Acoustic survey biomass by spawning area along coastal Nova Scotia with recent 5 year average (with CIF since 2003)

Survey SSB (t) with CIF	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	10% SSB Average Last 5 yr	10% SSB Average All years
Little Hope/Port Mouton						**53,100**	22,500	44,700	24,100	2,800	2,944	2,944
Halifax/Eastern Shore						92,600	28,400	36,950	68,900	28,300	5,103	5,103
Glace Bay						31,500		3,180	n/s	240	1,164	1,164
Bras d'Or Lakes						n/s	n/s	n/s	n/s	n/s	n/s	n/a

Note 1: shaded cells include mapping surveys; bold cells include mapping and acoustic surveys.
Note 2: data prior to 2003 calculated with the Calibration Integration Factor (CIF) are not available.

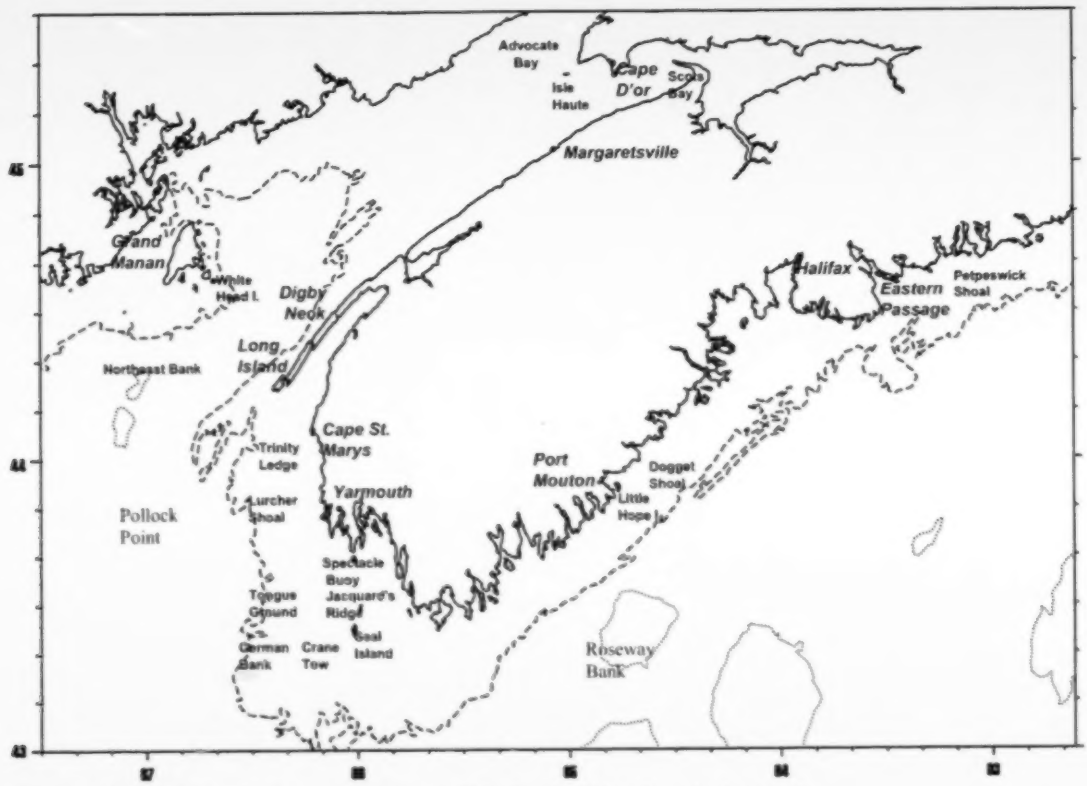

Figure 1. Map of the major spawning areas within the 4WX herring stock complex.

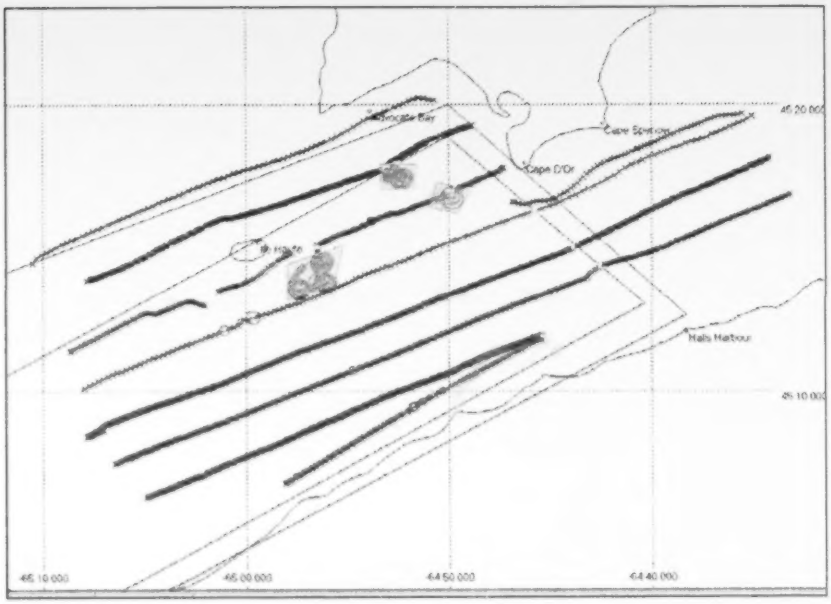

Figure 2. Scots Bay acoustic survey on July 14, 2007, showing transects inside the standard survey box, east of the survey box off Cape Spencer and north of survey box. The school transects completed are shown between the main survey lines.

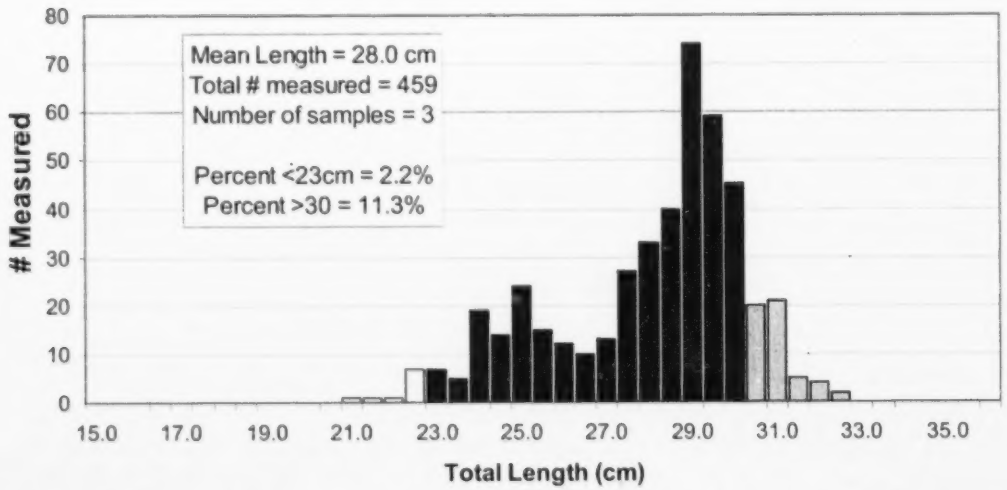

Figure 3. Length distribution from Scots Bay herring landings on July 15-16, 2007, with proportions <23 and >30cm. Bars are shaded white for sizes less than 23cm and grey for sizes greater than 30cm.

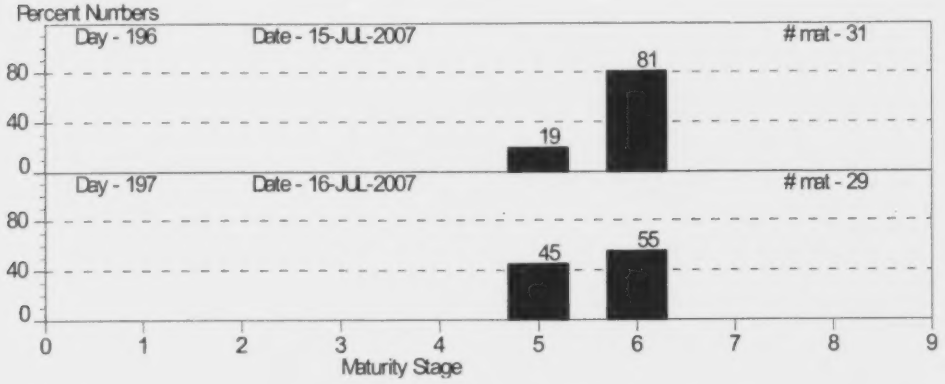

Figure 4. Herring maturity proportions by stage for Scots Bay samples collected from landings on July 15-16, 2007. (Stage 5 = maturing/hard; Stage 6 = ripe and running).

Figure 5. Scots Bay acoustic survey on July 28, 2007, showing total backscatter where schools were encountered as expanding circles.

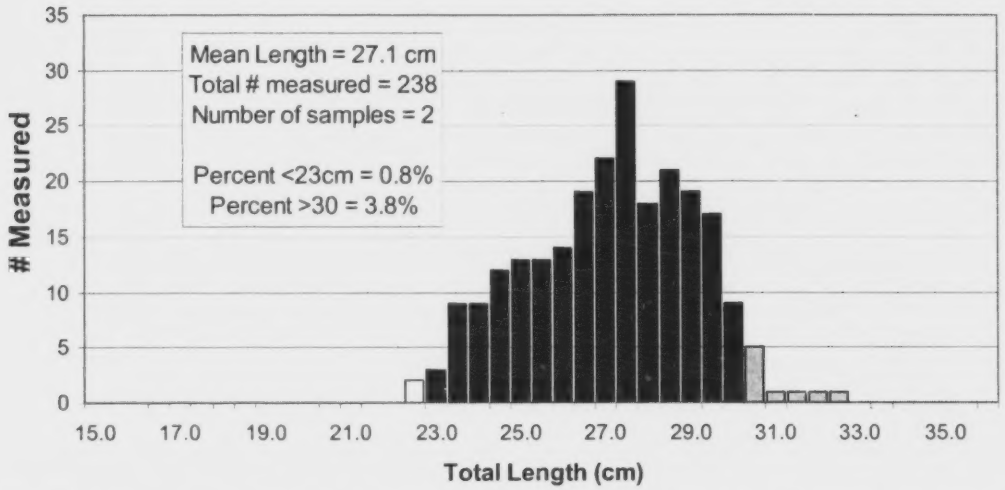

Figure 6. Length distribution for Scots Bay survey from landings on July 30th (caught on July 29th, the night after the survey) with proportions <23 and >30cm. Bars are shaded white for sizes less than 23cm and grey for sizes greater than 30cm.

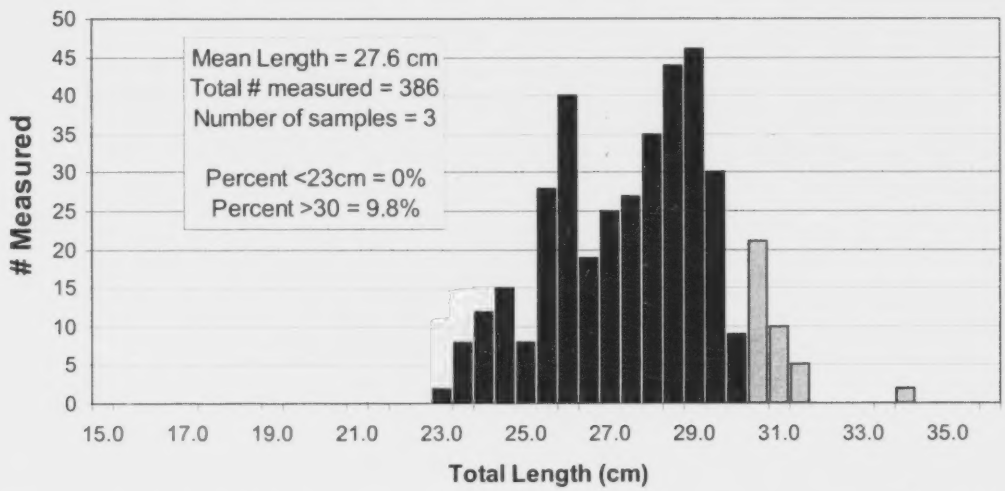

Figure 7. Length distribution for Scots Bay survey from herring landings on August 13th (caught on the night after the survey) with proportions <23 and >30cm. Bars are shaded white for sizes less than 23cm and grey for sizes greater than 30cm.

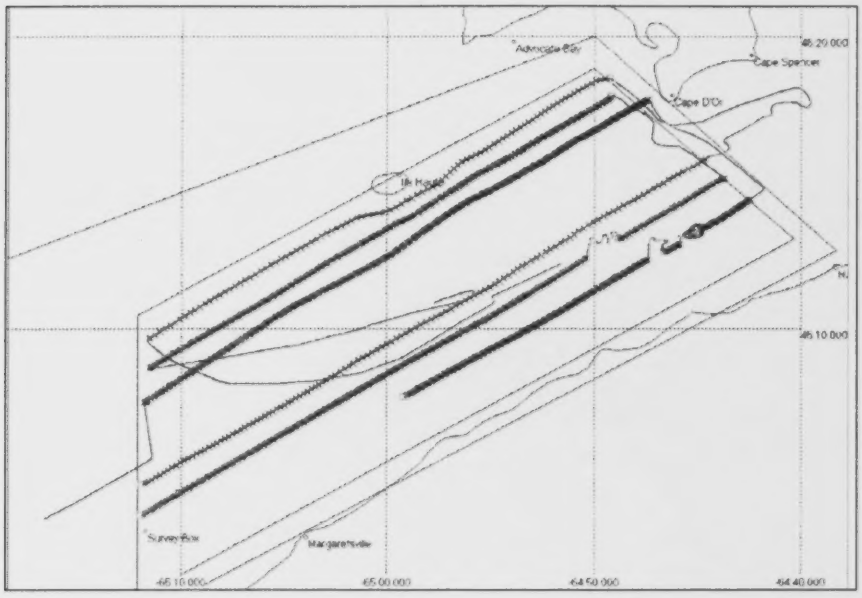

Figure 8. Scots Bay acoustic survey lines completed by vessels with FEMTO recording systems on August 11, 2007.

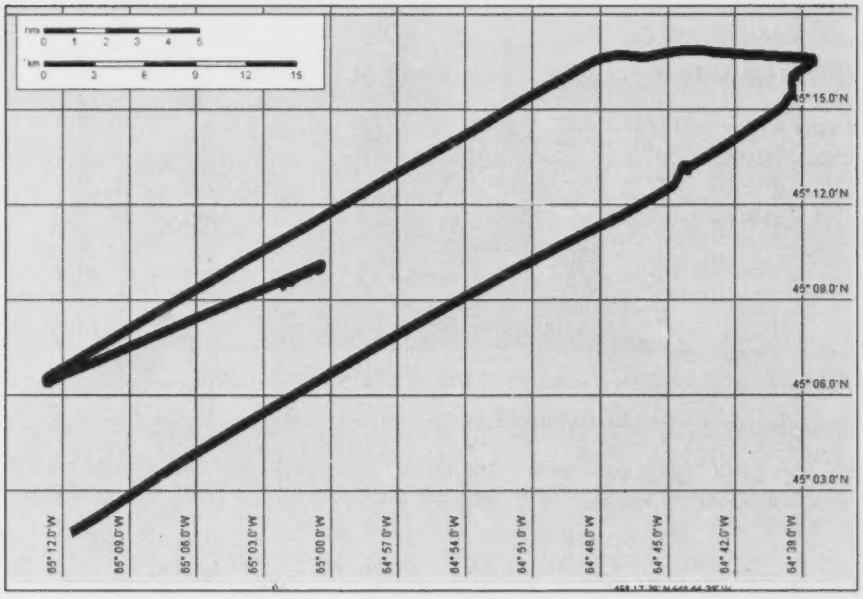

Figure 9. Scots Bay acoustic survey lines completed on August 11, 2007, by the *Morning Star* using a SIMRAD recording system.

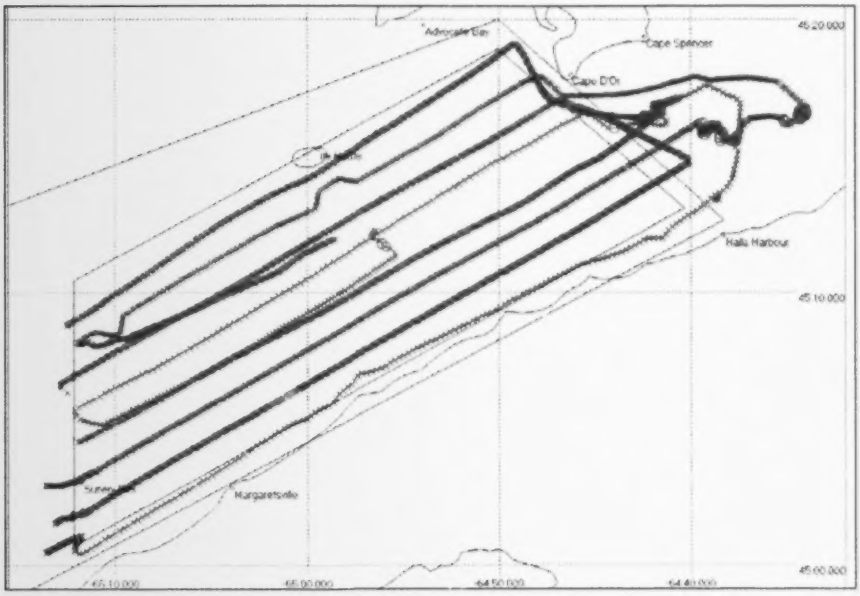

Figure 10. Scots Bay acoustic survey lines completed by vessels with FEMTO recording systems on August 25, 2007.

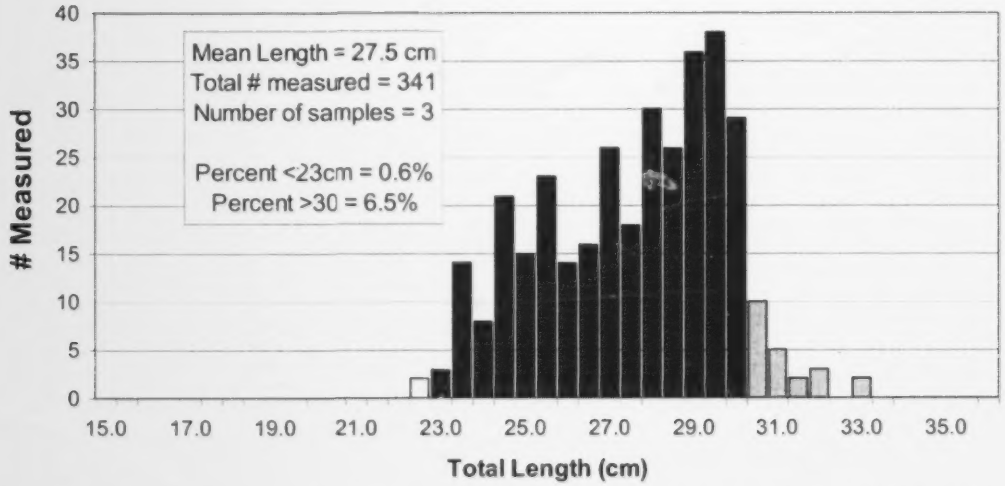

Figure 11. Length distribution for Scots Bay survey from herring landings on August 26th-27th (caught on evening after the survey) with proportions <23 and >30cm. Bars are shaded white for sizes less than 23cm and grey for sizes greater than 30cm.

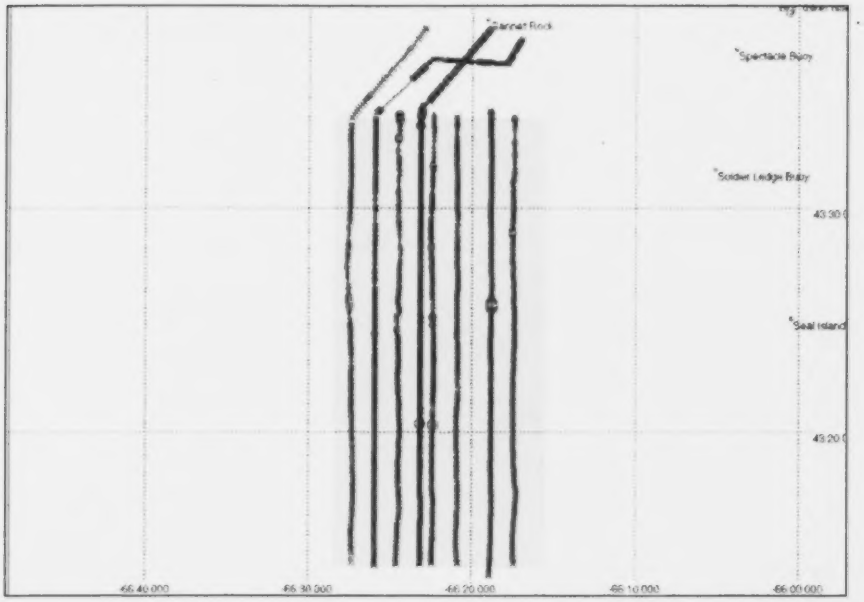

Figure 12. German Bank acoustic survey on August 24-25, 2007, with transects in the survey box and north of the box as recorded using FEMTO sounder systems.

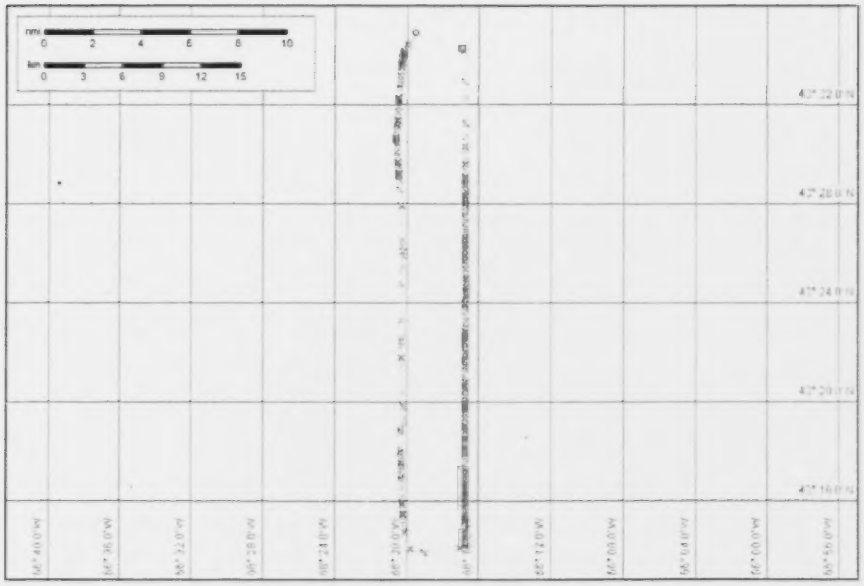

Figure 13. German Bank acoustic survey transects completed on August 24-25, 2007, by the *Morning Star* using a SIMRAD sounder recording system.

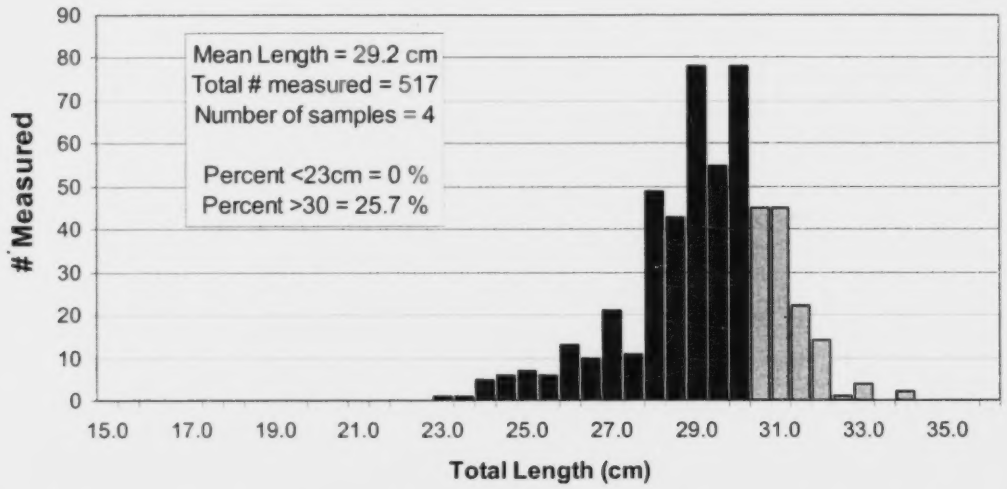

Figure 14. Length distribution used for calculation of target strength for the German Bank survey from herring landings on August 24th with proportions <23 and >30cm.

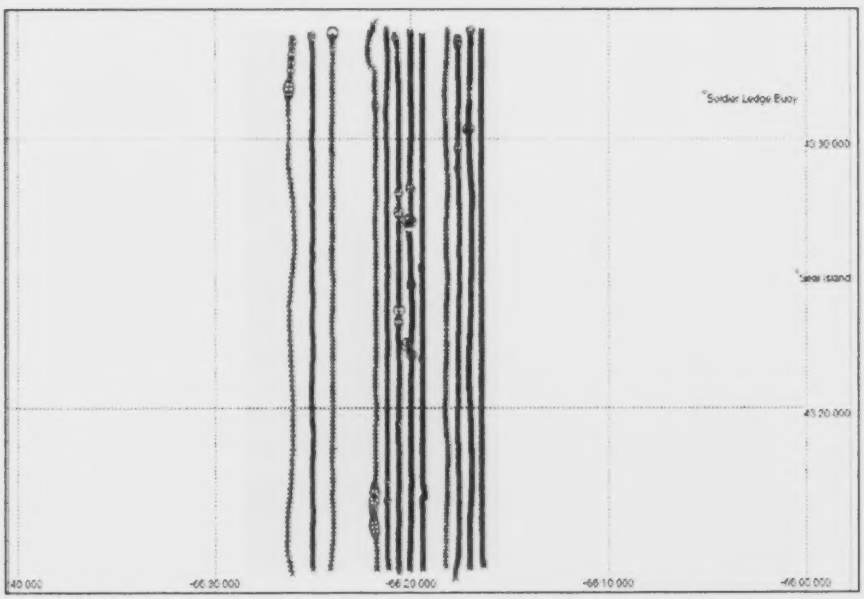

Figure 15. German Bank acoustic survey on September 7, 2007, with transects in the survey box and north of the box as recorded using FEMTO sounder systems.

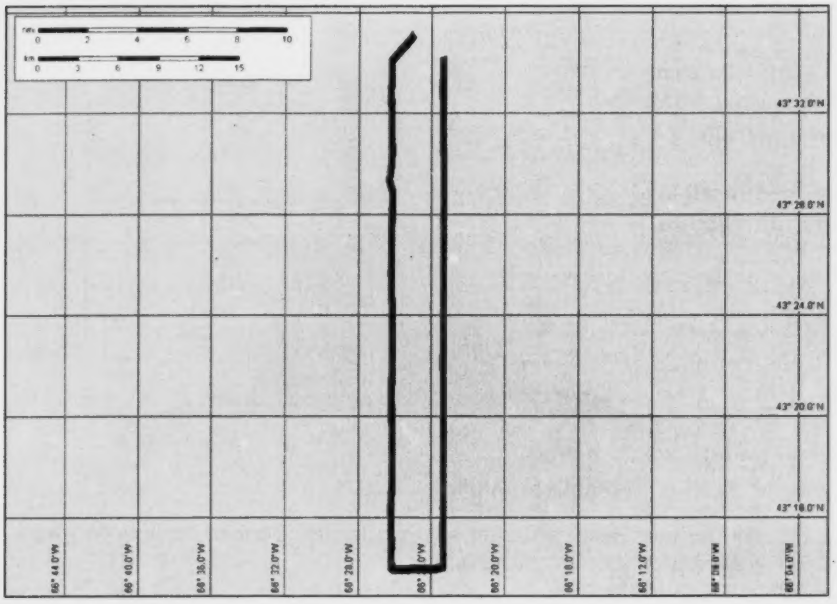

Figure 16. German Bank acoustic survey transects completed on September 7, 2007, by the *Morning Star* using a SIMRAD sounder recording system.

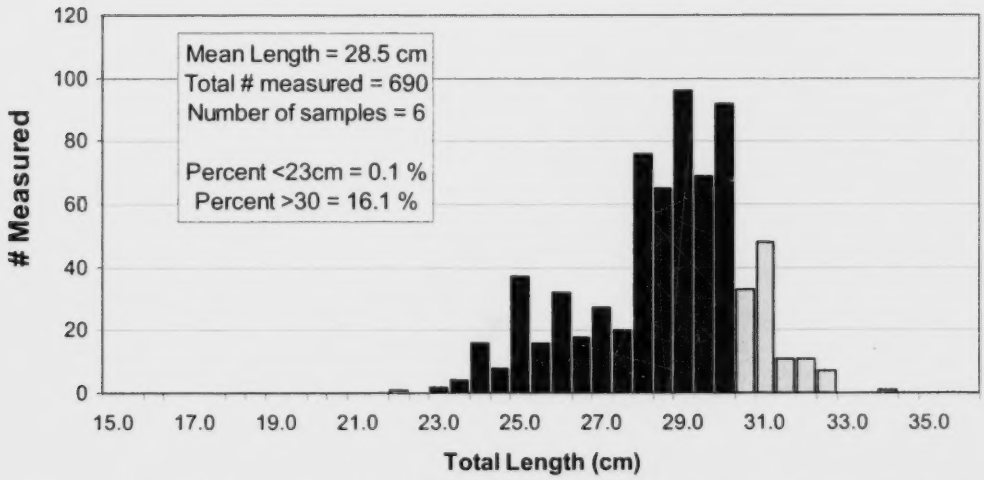

Figure 17. Length distribution used for calculation of target strength for the German Bank survey from herring landings on September 7th with proportions <23 and >30cm.

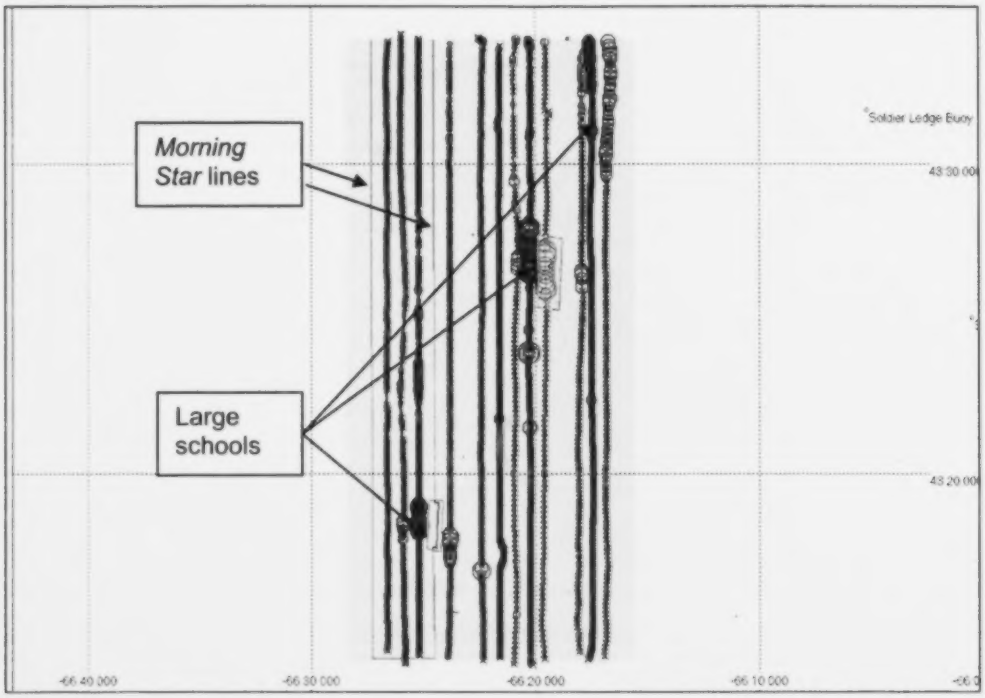

Figure 18. German Bank acoustic survey on September 21, 2007, showing location and backscatter (Sa) for transects in the survey box recorded using FEMTO sounder systems. The Simrad recorded transect locations are shown as a thin line and the locations of 3 large schools are also noted.

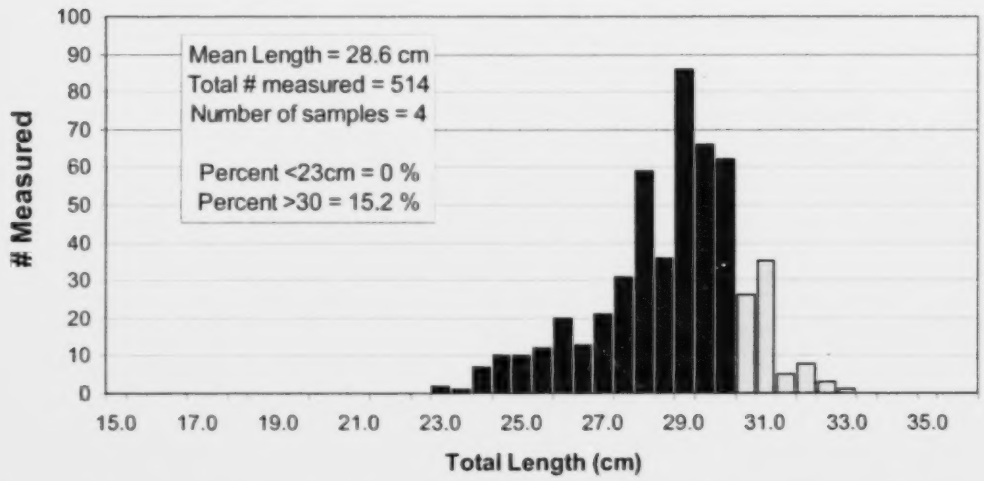

Figure 19. Length distribution used for calculation of target strength for the German Bank survey from herring landings on September 21st with proportions <23 and >30cm.

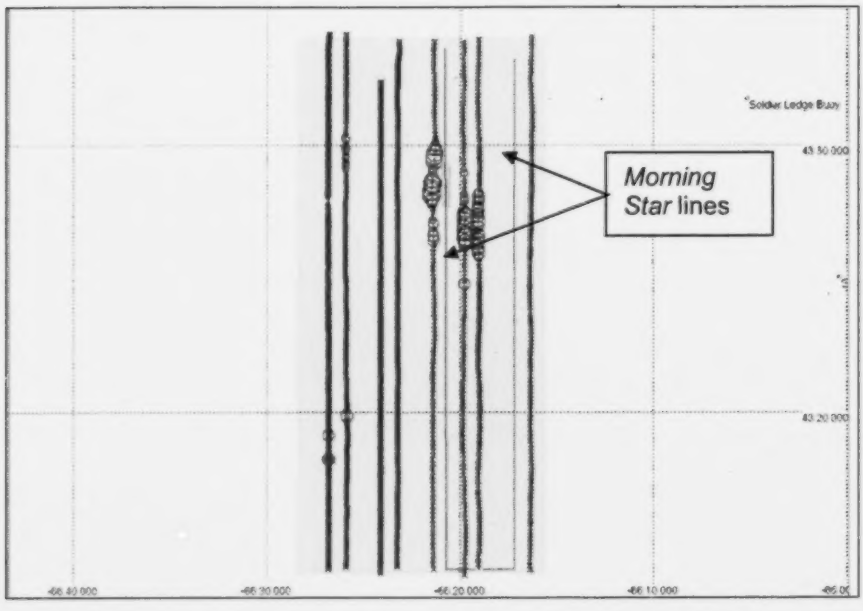

Figure 20. German Bank acoustic survey on October 5, 2007, showing location and backscatter (Sa) for transects in the survey box recorded using FEMTO sounder systems. The Simrad recorded transect locations by the *Morning Star* are also identified.

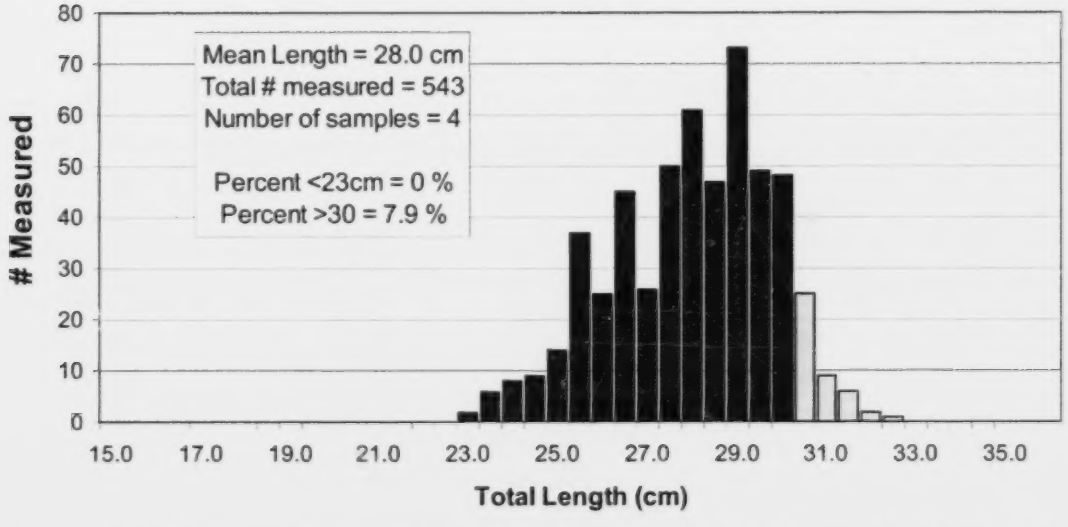

Figure 21. Length distribution used for calculation of target strength for the German Bank survey from herring landings on October 2nd and 5th with proportions <23 and >30cm.

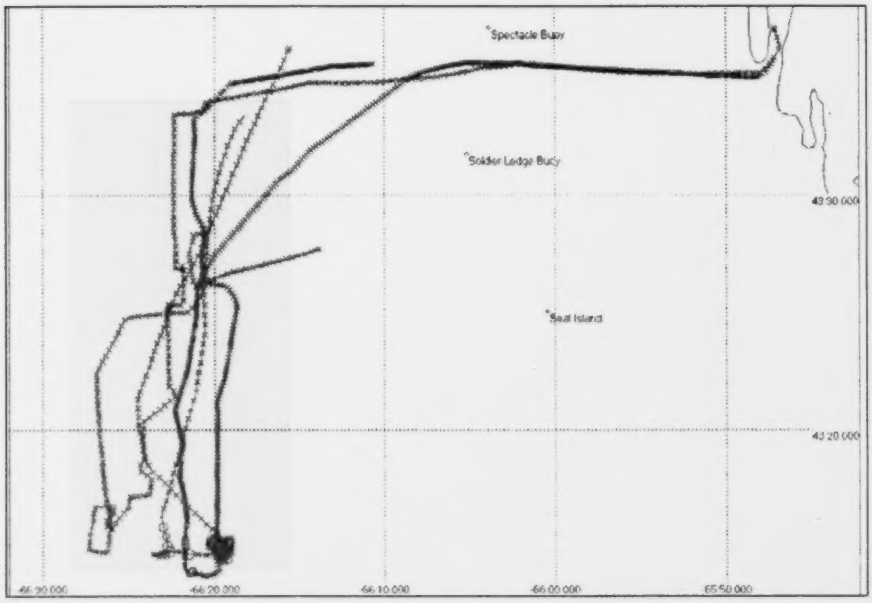

Figure 22. German Bank acoustic survey on October 17, 2007, showing the location of survey lines and backscatter (Sa) or location of fish as expanding circles.

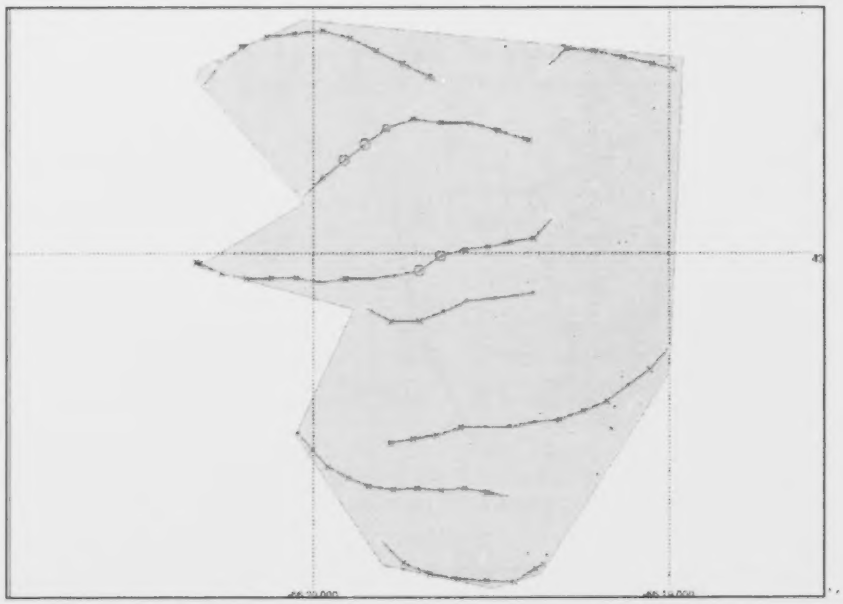

Figure 23. Survey lines completed along an east-west axis for a school located on the southeast part of German Bank on October 17, 2007, with an estimated area of 2.77km^2.

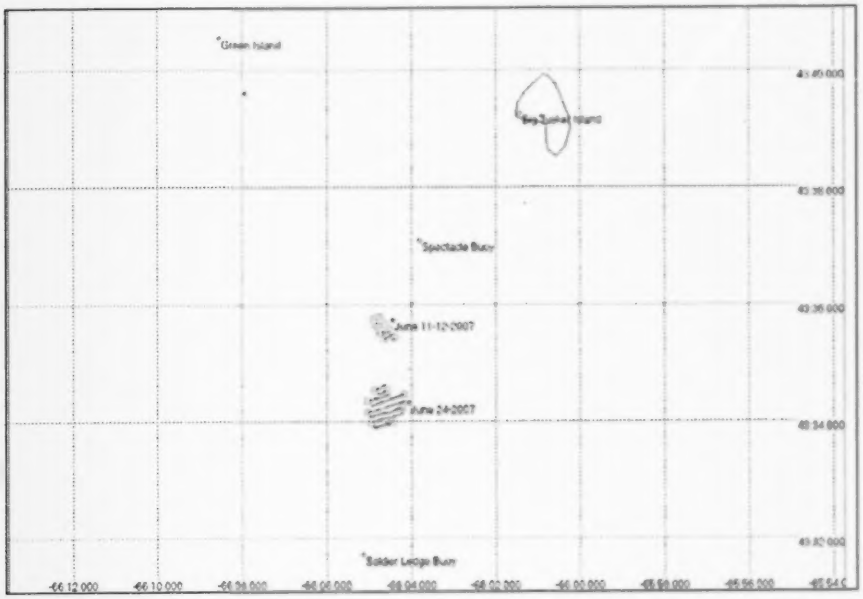

Figure 24. Location of herring acoustic surveys on June 11th, 12th and June 24th near Spectacle Buoy.

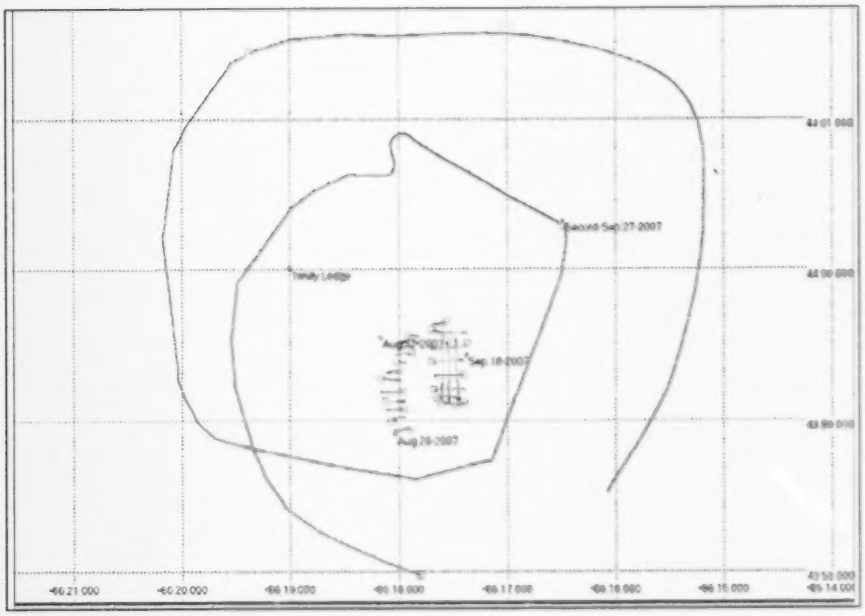

Figure 25. Location of herring acoustic surveys for 2007 in the Trinity Ledge area including the vessel track by *Secord* on September 27, 2007.

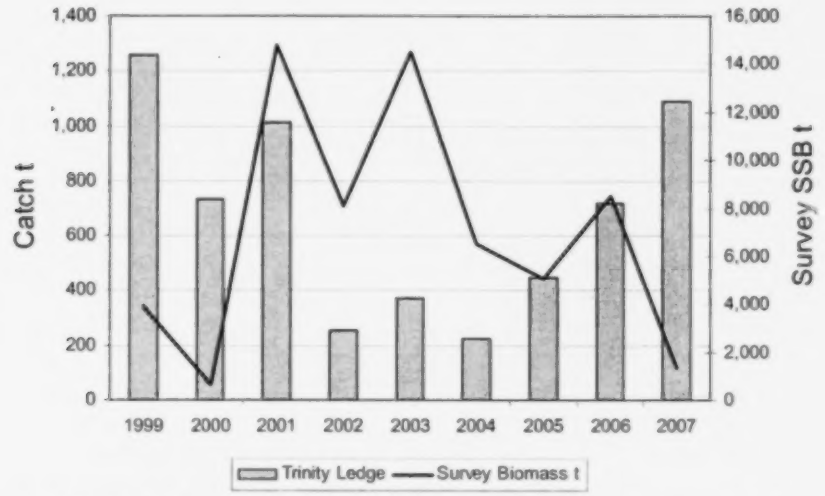

Figure 26. Trinity Ledge herring catches and acoustic survey biomass estimates from 1999 to 2007. Acoustic estimates were calculated without the CIF.

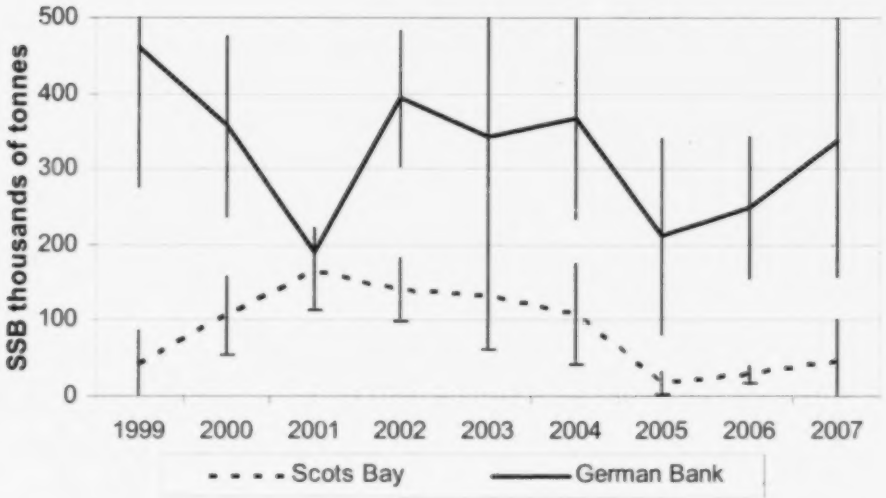

Figure 27. Trends in herring spawning stock biomass from acoustic surveys in Scots Bay and German Bank areas with 95% confidence intervals (equivalent to 2 times SE).

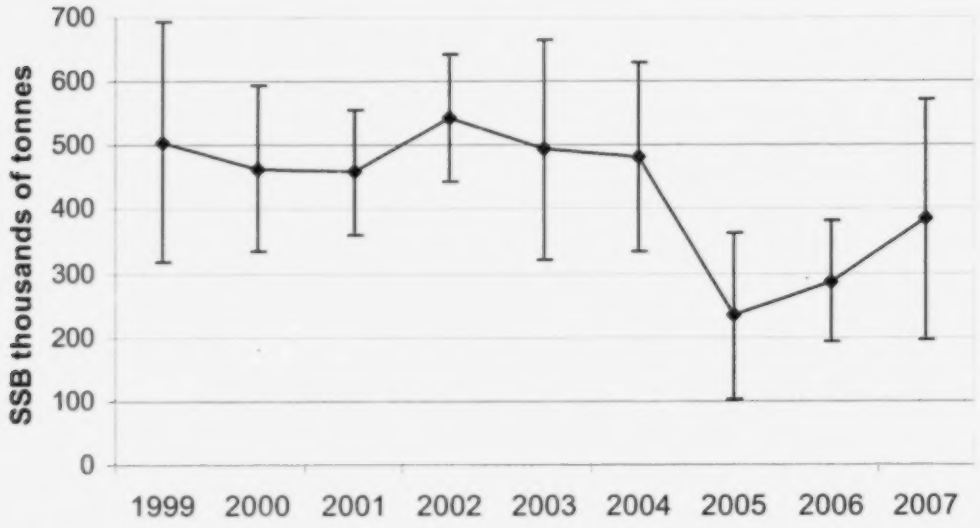

Figure 28. Trends in herring spawning stock biomass from acoustic surveys for the combined SWNS areas with 95% confidence intervals (equivalent to 2 times SE).

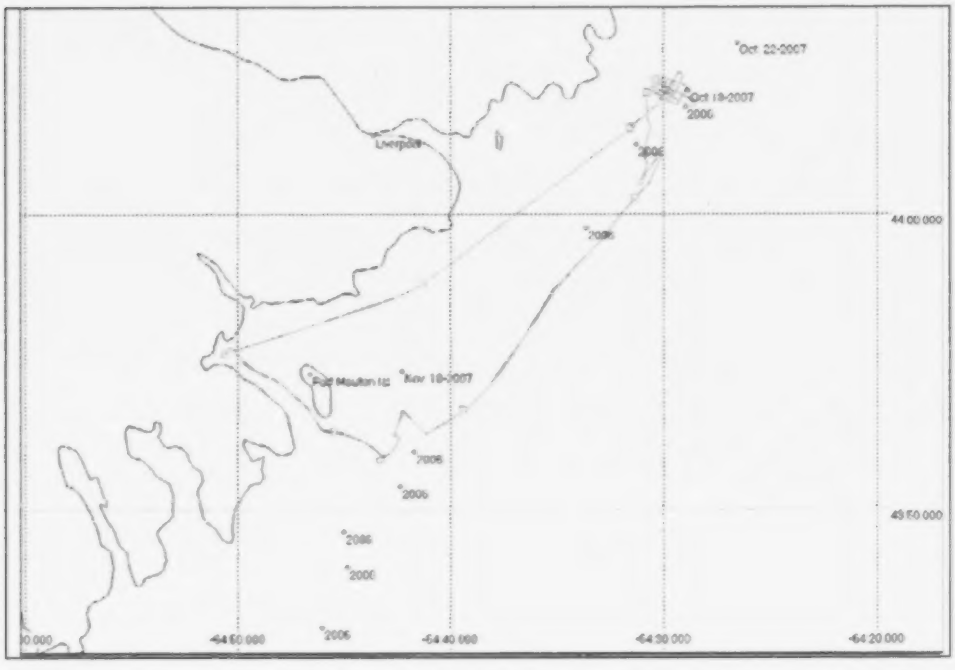

Figure 29. Acoustic survey lines for October 18, 2007, in the Little Hope/Port Mouton Fishing area with the locations of the other 2007 and previous year 2006 surveys also shown.

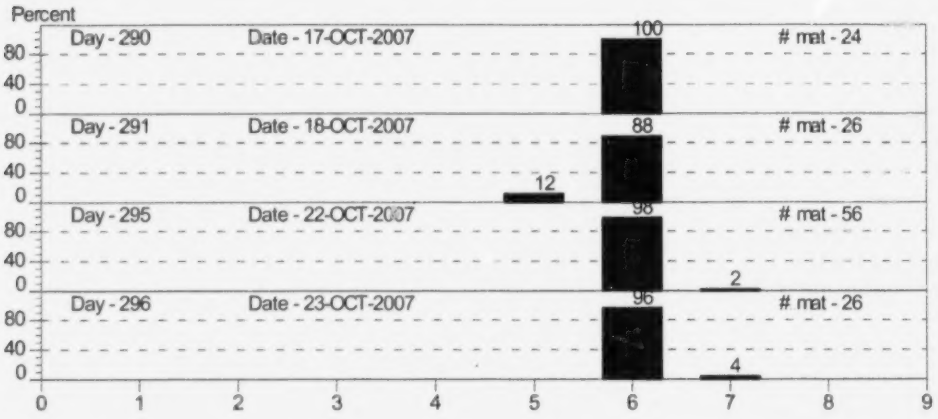

Figure 30. Herring maturities (% number by stage) for the 2007 Little Hope/Port Mouton area as processed at SABS (Stage 5 is hard roe, Stage 6 is ripe and running and Stage 7 is spent).

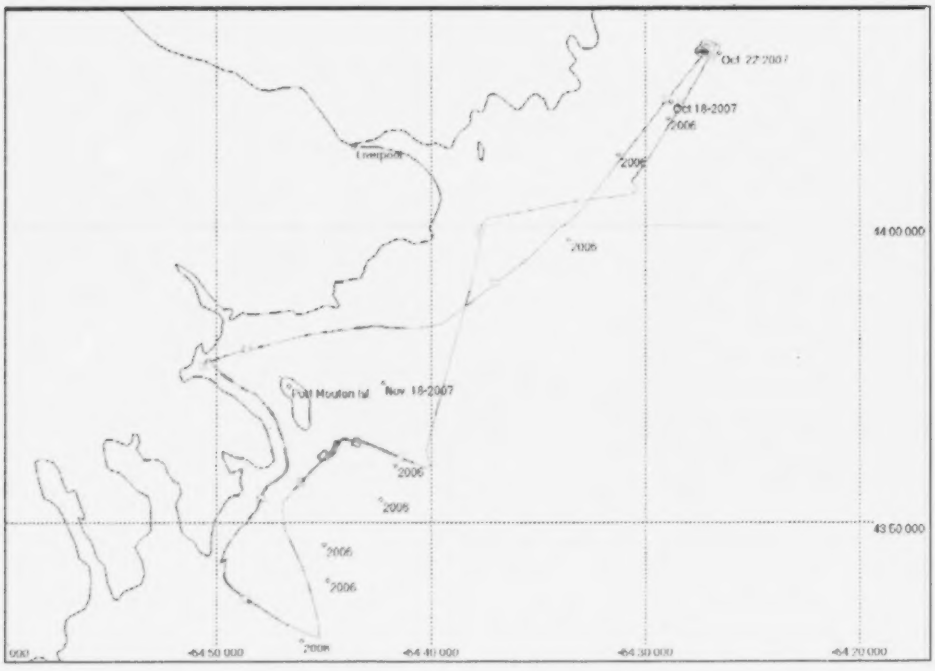

Figure 31. Acoustic survey lines for October 21, 2007, in the Little Hope/Port Mouton Fishing area with the locations of the other 2007 and previous year 2006 surveys also shown.

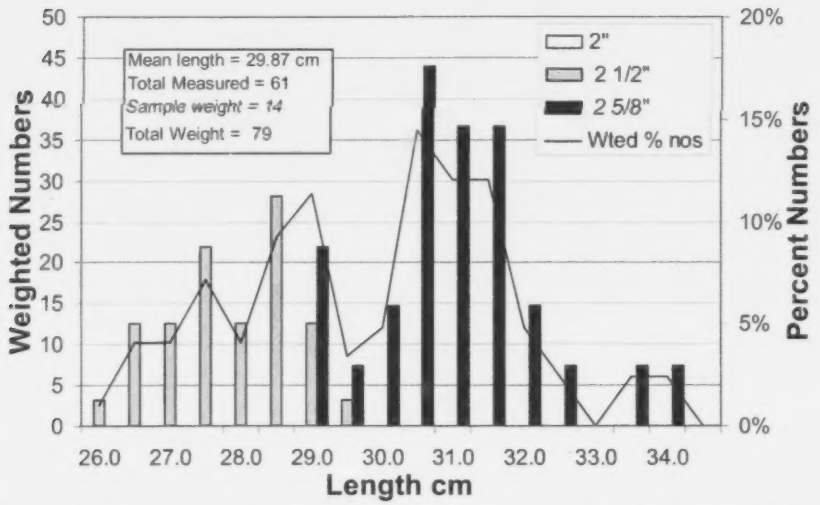

Figure 32. Multi-panel gillnet sample for the herring acoustic survey collected on October 22, 2007, from the Little Hope/Port Mouton area. Separate panels were used with mesh size of 1-1/2", 2", 2-1/2" (as used in fishery) and 2-7/8".

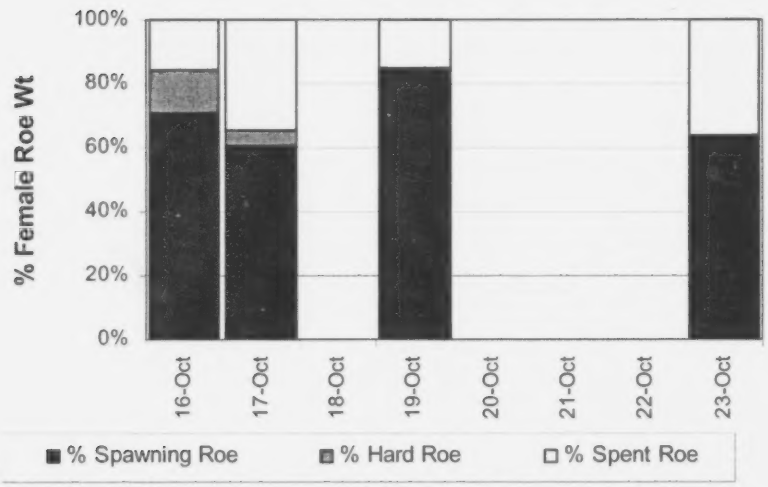

Figure 33. Daily herring female roe samples (% roe weight) from industry sources for the Little Hope/Port Mouton area in 2007.

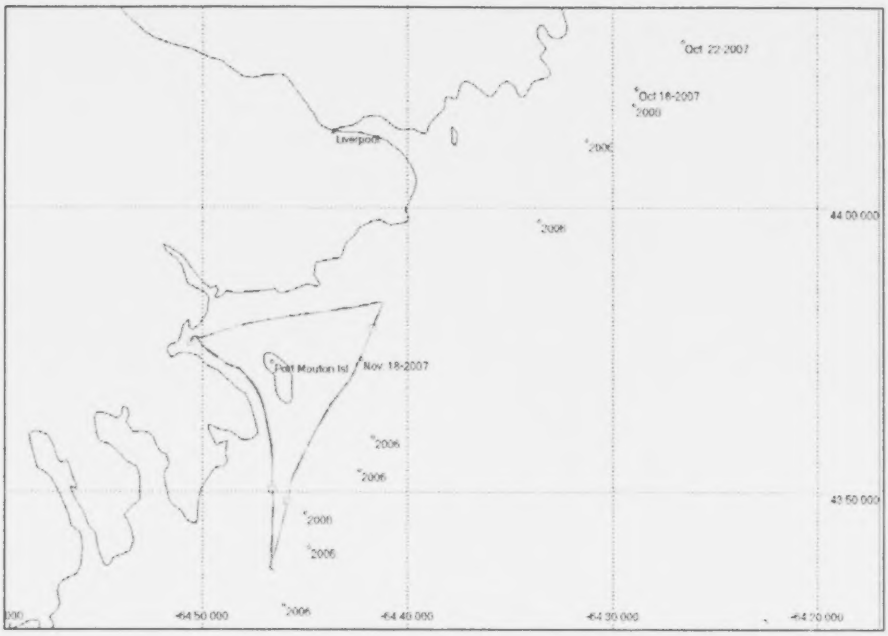

Figure 34. Acoustic survey lines for November 18, 2007, in the Little Hope/Port Mouton Fishing area with the locations of the other 2007 and previous year 2006 surveys also shown.

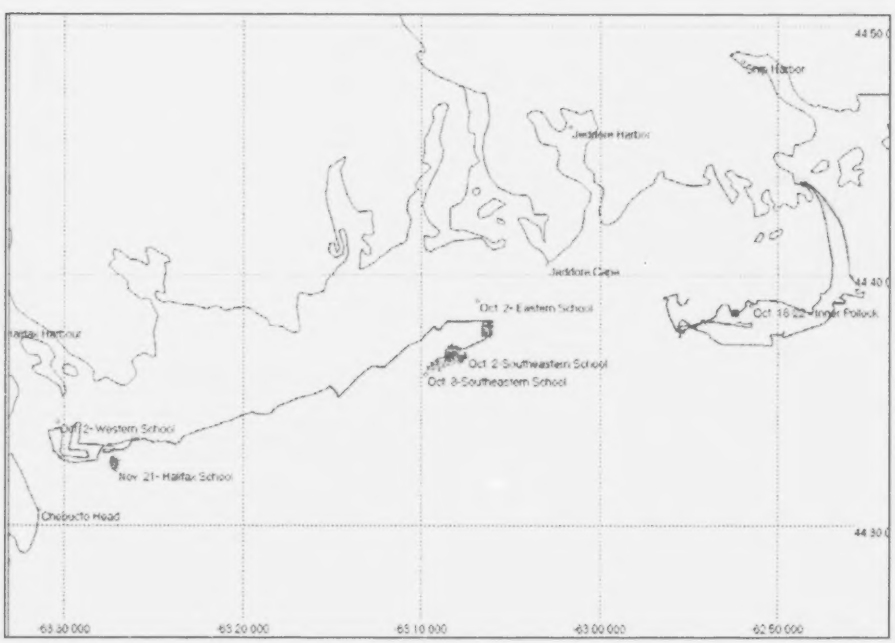

Figure 35. Acoustic lines completed for surveys on October 2nd, October 8th, October 22nd and November 20th along the Eastern Shore fishing area by the *Bradley K* and *Miss Owls Head*.

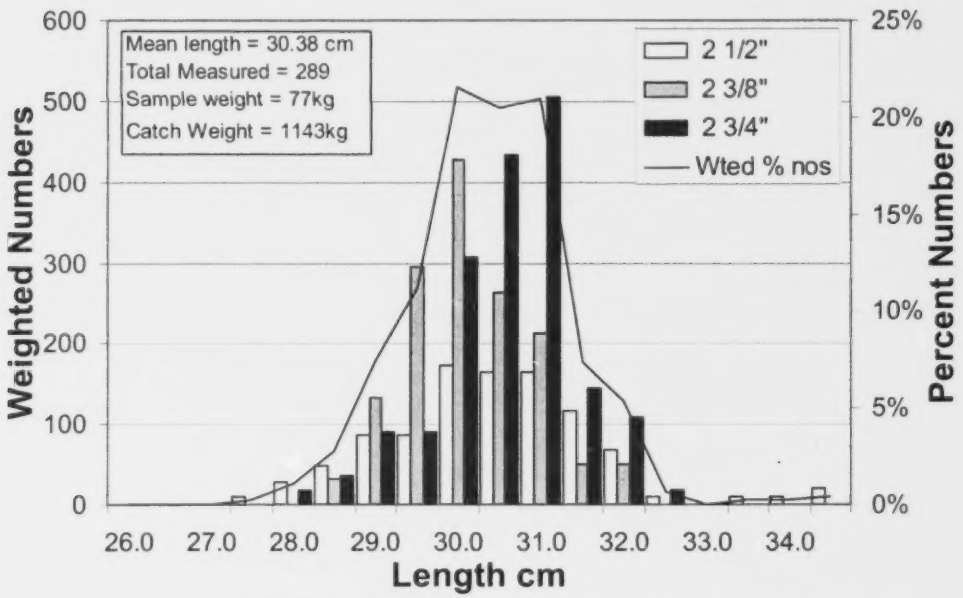

Figure 36. Multi-panel gillnet samples combined for October 2nd and October 8th herring acoustic surveys in the Eastern Shore fishing area.

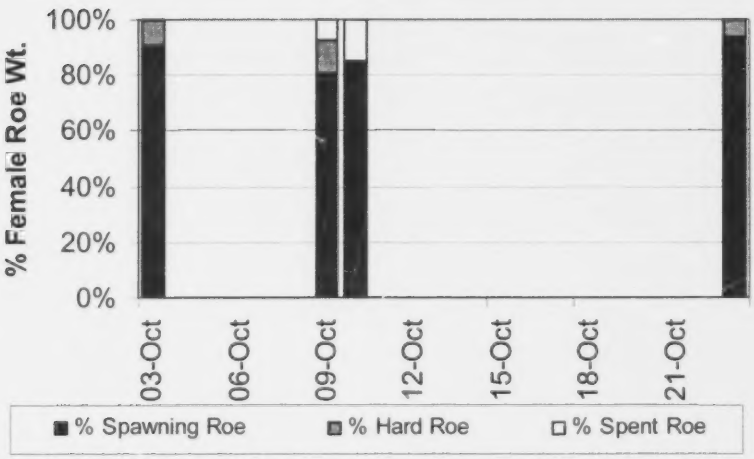

Figure 37. Herring roe samples from Industry (% female roe weight) for 2007 from the Eastern Shore area.

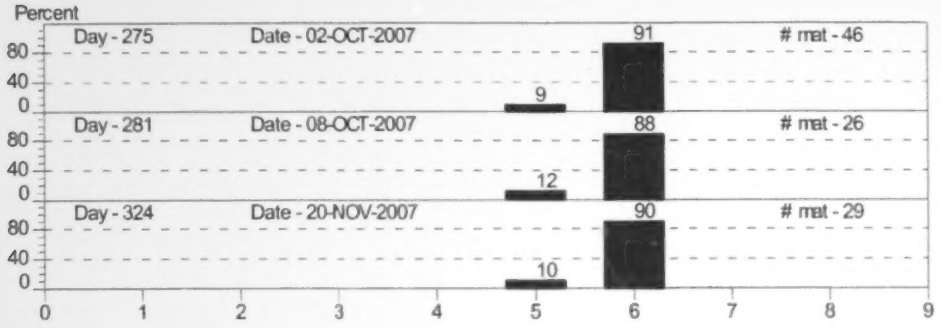

Figure 38. 2007 daily maturity samples by stage for Eastern Shore area as processed by SABS (Stage 5 = maturing/hard, Stage 6 = ripe and running).

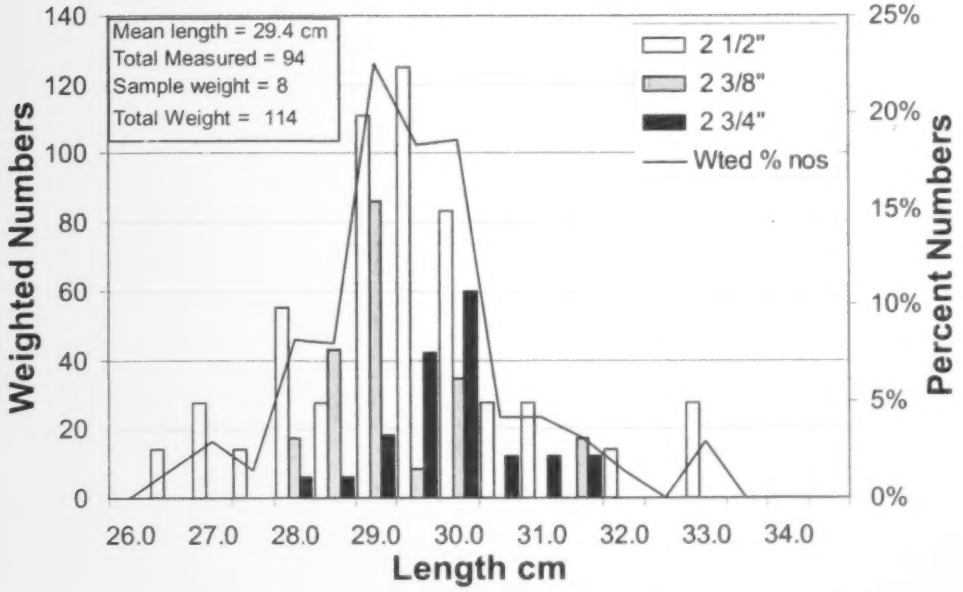

Figure 39. Multi-panel herring gillnet sample for November 21st acoustic survey in the Eastern Shore fishing area.

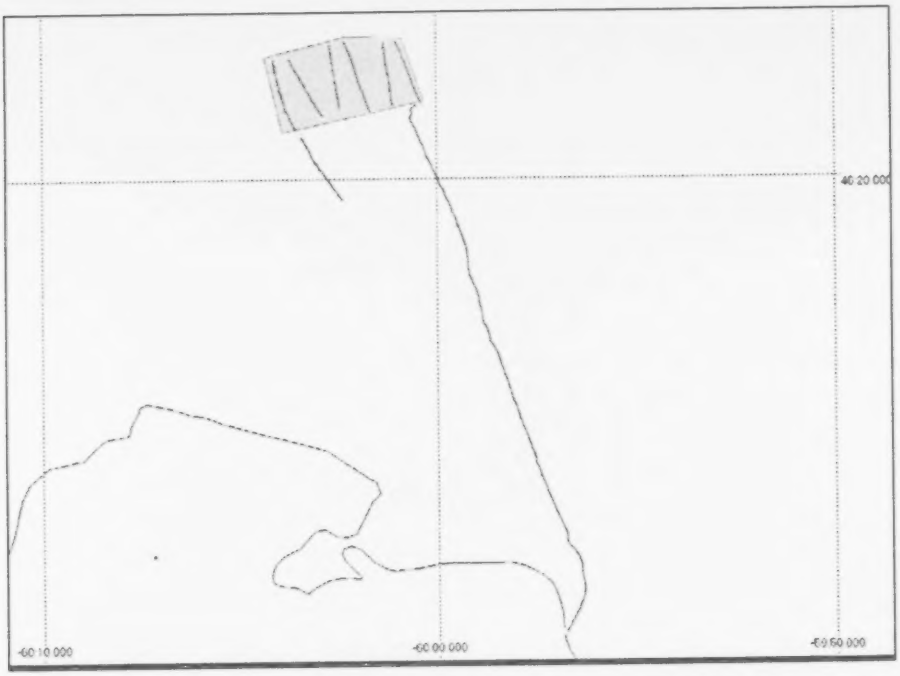

Figure 40. Acoustic searching track and estimation of school area for the September 14, 2007, Glace Bay herring survey.

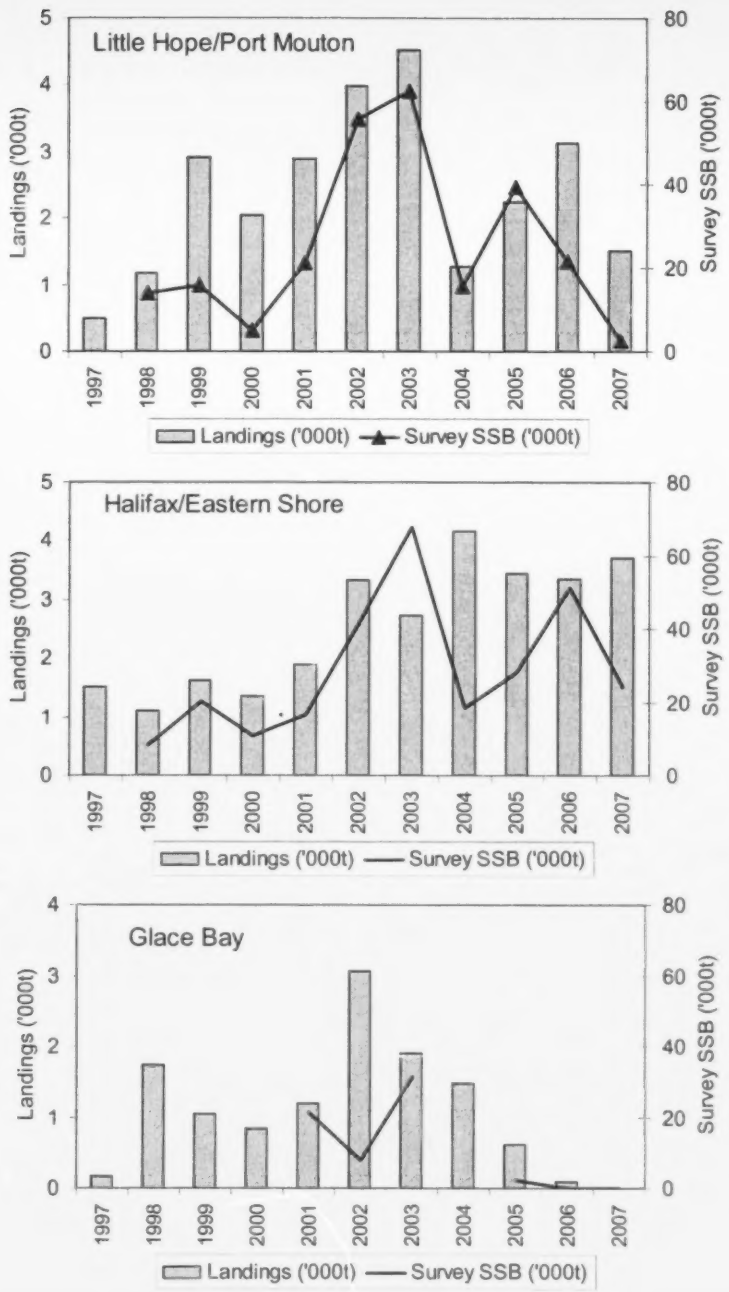

Figure 41. Summary of landings (bars) and surveyed biomass as calculated without the CIF (solid line) for the coastal Nova Scotia herring spawning areas near Little Hope/Port Mouton, Halifax/Eastern Shore and Glace Bay.